Research Branch
Directory of Research

1998 - 1999

Agriculture
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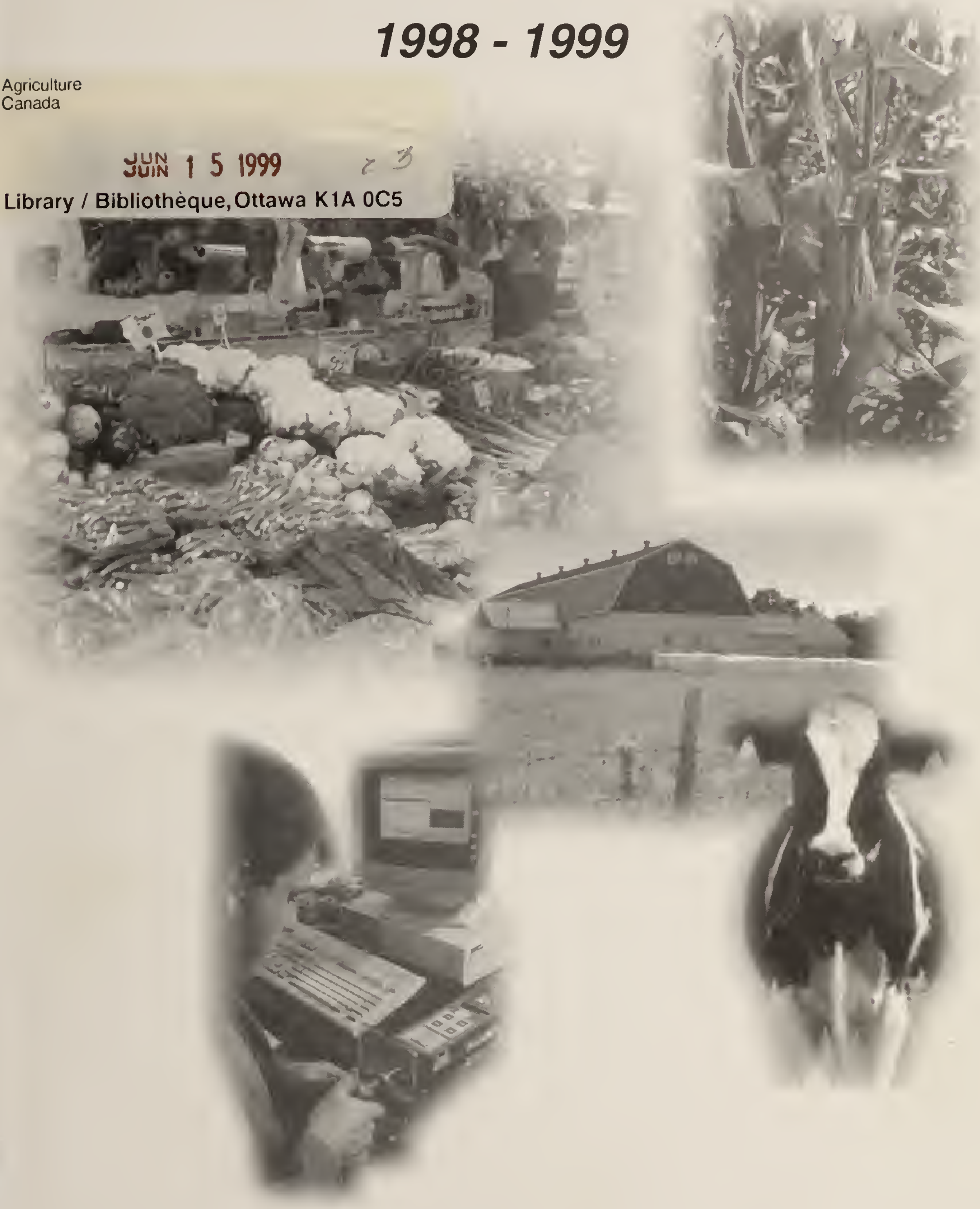

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Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Research Branch
Direction générale de la recherche

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1998 - 1999

Research Branch

Agriculture and Agri-Food Canada
Publication 1996/E
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A Word from our ADM

Welcome to the *Directory of Research.* In this directory you will find everything you need to contact us at the Research Branch of Agriculture and Agri-Food Canada.

The job of the Research Branch is to support the efforts of Canada's agri-food sector to develop and produce competitive products in an environmentally sustainable manner. To accomplish this, we have 18 research centres, located right across Canada and in every province. In 1997-1998 we spent a total of $292 million, including major capital and benefits.

Each of our research centres has a specialized national focus, placing emphasis on the particular strengths of the local agricultural and agri-food sector. These specialized centres provide one-stop shopping for key areas of agri-food research.

Other commodities that cover a broad spectrum of ecozones are served by comprehensive networks of centres. Our network approach allows us to deal with research challenges at many levels, from managing our resources, to breeding new crop varieties, to protecting crops against pests, and to developing new and innovative Canadian food products for domestic and international markets.

For us to be successful, we must communicate effectively with our clients and research partners in industry, universities, and governments. The *Directory of Research* for 1998–1999 is one important way we help foster this communication. It is intended to help our clients and partners get in touch with us to access information and explore collaborative opportunities.

Please consider this directory as a door to the Research Branch. Behind it you will find each of our 18 research centres with information about their staff, mandate, resources, achievements, and publications. You will also find information on the Branch's headquarters.

The *Directory of Research* is available as a printed publication and on-line to provide you with information in a format that best suits your needs. You can find the directory on ACEIS, Agriculture and Agri-Food Canada's 24-hour Electronic Information Service. For information on how to obtain printed or electronic copies of this publication, please see the instructions on the back of the title page.

It is our hope that producers, businesses, researchers, students, and government officials, nationally and internationally, will take advantage of this directory to guide them in their search for information and contacts concerning our programs, our centres, and our people. We invite you to get in touch with us.

Brian Morrissey, Assistant Deputy Minister, Research

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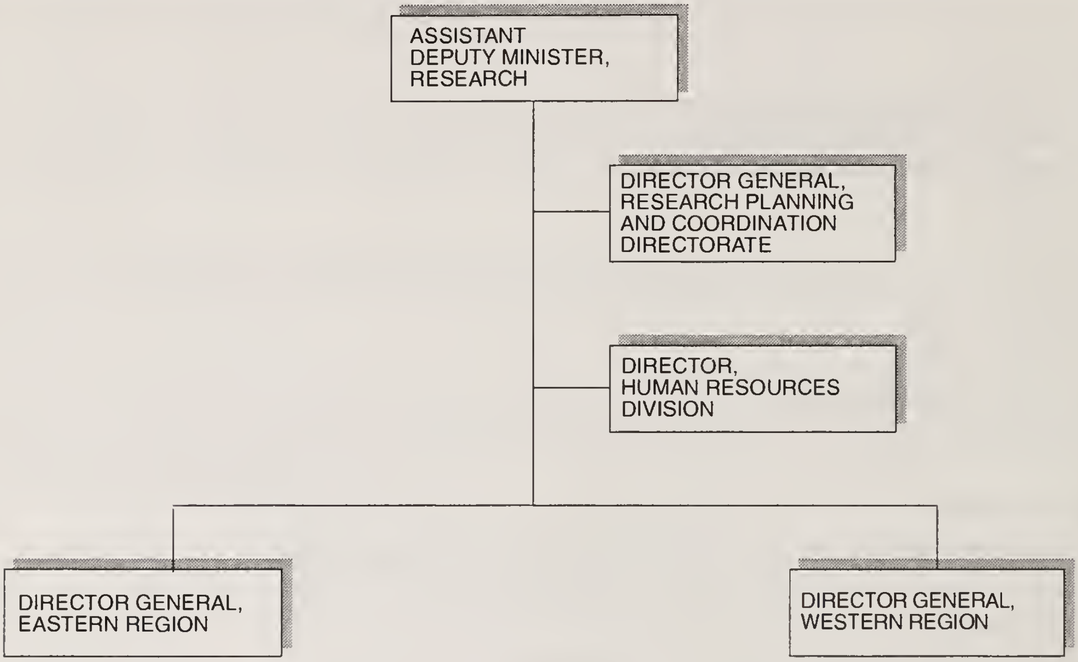
ORGANIZATION OF THE RESEARCH BRANCH


ASSISTANT DEPUTY MINISTER, RESEARCH
DIRECTOR GENERAL, RESEARCH PLANNING AND COORDINATION DIRECTORATE
DIRECTOR, HUMAN RESOURCES DIVISION
DIRECTOR GENERAL, EASTERN REGION
DIRECTOR GENERAL, WESTERN REGION

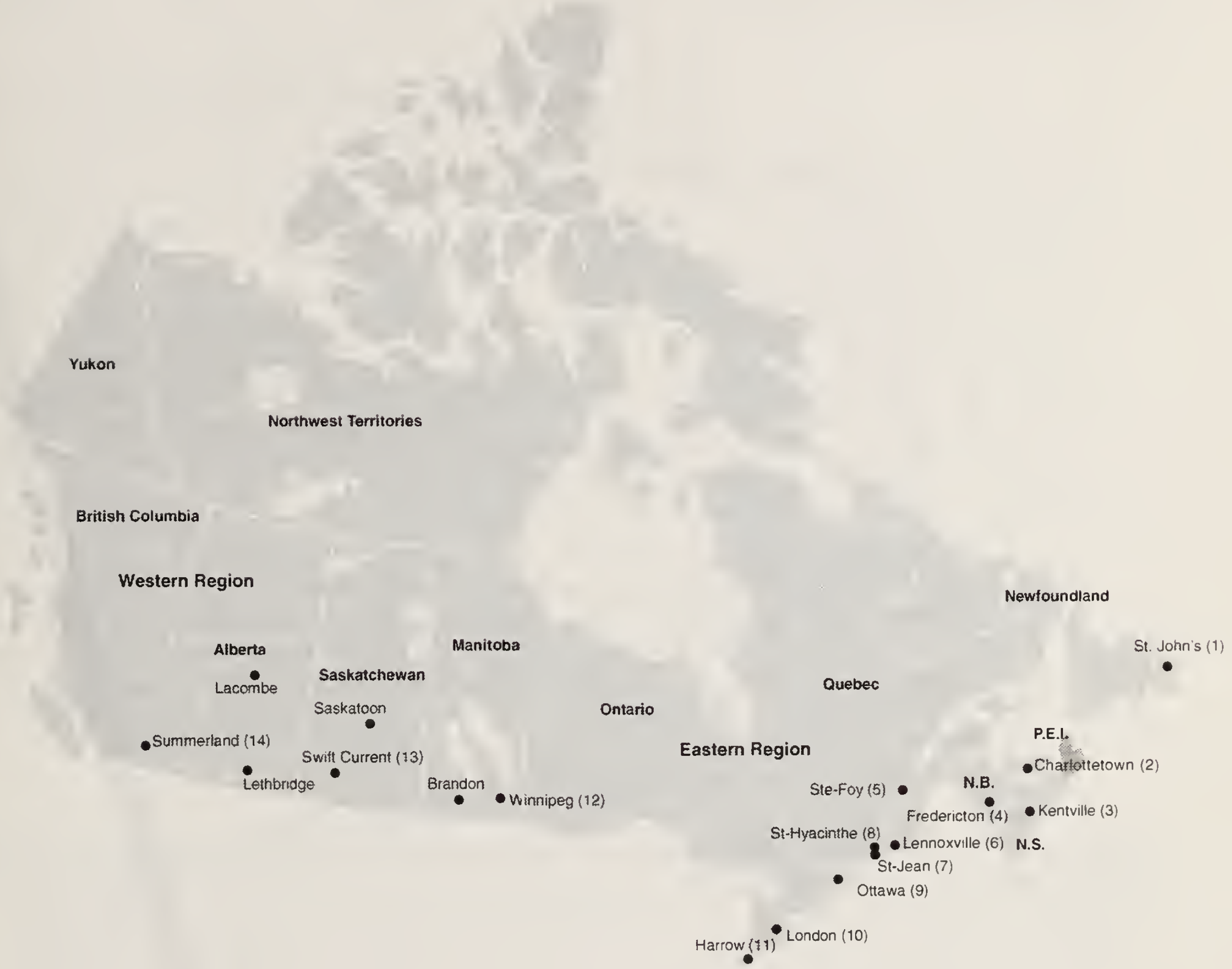
Research Centres

Atlantic Cool Climate Crops (1)
Crops and Livestock (2)
Atlantic Food and Horticulture (3)
Potato (4)
Soils and Crops (5)
Dairy and Swine (6)
Horticulture (7)
Food (8)
Eastern Cereal and Oilseeds (9)
Southern Crop Protection and Food (10)
Greenhouse and Processing Crops (11)

Cereal (12)
Brandon
Saskatoon
Semiarid Prairie Agriculture (13)
Lethbridge
Lacombe
Pacific Agri-Food (14)

See Map (p. 3) for location of the research establishments keyed by number

MAP OF MAJOR RESEARCH CENTRES



See Organization of the Research Branch (p. 2) for key to the Branch's research centres.

PROGRAMS AT MAJOR RESEARCH CENTRES

	Centres	Eastern Region											Western Region						
	Branch programs	Atlantic Cool Climate Crop Research Centre (St. John's)	Crops and Livestock Research Centre (Charlottetown)	Atlantic Food and Horticulture Research Centre (Kentville)	Potato Research Centre (Fredericton)	Soils and Crops Research and Development Centre (Sainte-Foy)	Dairy and Swine Research and Development Centre (Lennoxville)	Horticulture Research and Development Centre (Saint-Jean-sur-Richelieu)	Food Research and Development Centre (Saint-Hyacinthe)	Eastern Cereal and Oilseed Research Centre (Ottawa)	Southern Crop Protection and Food Research Centre (London)	Greenhouse and Processing Crops Research Centre (Harrow)	Cereal Research Centre (Winnipeg)	Brandon Research Centre	Saskatoon Research Centre	Semiarid Prairie Agricultural Research Centre (Swift Current)	Lethbridge Research Centre	Lacombe Research Centre	Pacific Agri-Food Research Centre (Summerland)
Resources	Land		●		●	●				●	●	●		●	●	●	●	●	●
	Germplasm / pests & biocontrol				●					●		●	●		●		●		
Crops	Cereals		●			●				●			●	●		●	●	●	
	Oilseeds									●		●	●		●			●	
	Forages	●	●			●									●	●	●	●	●
	Field crops										●		●			●	●		
	Vegetables	●	●	●	●			●			●	●					●		●
	Tree fruits & berries			●				●			●								●
	Ornamentals										●		●						
Animals	Beef				●		●							●			●		
	Dairy						●												
	Swine						●												
	Poultry																		●
	Other animals																	●	
Food	Animal products & processes								●									●	
	Crop products & processes			●					●		●				●				●
	Nonfood products & processes			●					●		●				●				

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RESEARCH BRANCH DIRECTORY OF RESEARCH 1998 - 1999

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International and biotechnology D. Kudirka, Ph.D.
Food and industrial research G.E. Timbers, Ph.D.
Animal research S.K. Ho, Ph.D.

Mandate

The Research Planning and Coordination Directorate assists the Assistant Deputy Minister and directors general in providing corporate services to support agri-food research and technology-transfer programs. RPC's work facilitates

- administration
- financial decision making
- promotion
- information management
- research coordination and issues management, nationally and internationally
- planning and formulation of science policy
- human resources management.

The information the directorate produces is used federally, provincially, and abroad by

- the agri-food industry (farmers, producers, and processors, and their associations)
- government and other funding powers (senior departmental executives and politicians developing science policy)
- the scientific community (academics and specialists studying agriculture and the environment)
- the public (students, reporters for the farm and general media, and a concerned public wishing to influence science policy).

Resources

In 1997–1998, when the achievements presented in this report were completed, the directorate spent $5.5 million through their operating budget. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

Achievements

- *Support services for Matching Investment Initiative*
- *New development for Science and Technology Strategy*
- *Coordination of Research Branch Advisory Committee meeting*
- *Preparation of business-line plan*
- *New tools for ethical research*
- *Representation in Federal Partners in Technology Transfer*
- *Enhanced awareness of tax credits*
- *Corporate sponsorship of R&D Impact Network*
- *New research initiatives for biotechnology*
- *Consultations with universities*
- *Briefing for testimony to standing committees*
- *Participation in tetrapartite meetings*
- *Support for interdepartmental cooperation*
- *Implementation of Science Horizons*
- *Coordination of Year-2000 activities*
- *Development of Environmental Management Program*
- *Implementation of Storage Tank Management Program*
- *Provision of research information*
- *Enhancement of the Study Management System*
- *New capabilities of the Microcomputerized Management Information Processing System*
- *New direction toward strategic promotion*
- *Promotion of sustainable development in agriculture*
- *Promotion of collaborative opportunities through corporate publishing*
- *Production of two key reports*
- *Participation in National Public Service Week*
- *Selection for university grants*
- *Support for international multilateral organizations*
- *Support for international agreements and activities*
- *Support for federal branches, departments, and agencies*
- *Offers to visiting fellows*
- *Major Capital update*
- *Demographic and statistical report*
- *Pilot project for hiring*
- *Employment Equity Plan*
- *Human Resources Plan*
- *Coordination of Universal Classification System*
- *Support for science and technology*
- *Participation in the Science & Technology Interdepartmental Committee*

Support services for Matching Investment Initiative

The directorate provides services to support the Matching Investment Initiative (MII), which aims to

- strengthen market-driven priority setting in the branch

- accelerate the transfer of technology.

The program matches industry dollars for projects that are within the core capability of the branch. In fiscal year 1997–1998
- 930 projects were approved in Agriculture and Agri-Food Canada
- the federal contribution, including that of the Canadian Food Inspection Agency, totaled about $28.9 million
- the total value of the MII reached $60.4 million, including industry contributions of about $31.5 million.

The MII page on the Internet includes success stories from across the branch. It is available at http://www.agr.ca/research/branch/match.html.

New development for Science and Technology Strategy On behalf of the Research Branch, the directorate has been involved in several interdepartmental initiatives in support of the federal Science and Technology Strategy. Included was the development of an annual report for the Office of the Auditor General.

Coordination of Research Branch Advisory Committee meeting The directorate coordinates meetings of the Research Branch Advisory Committee, whose members are from the private sector. The committee met in April 1998 in Kentville, N.S. The committee
- advises the department on research priorities and resource allocation across research activities
- provides input on strategic directions proposed by the Research Branch.

Preparation of business-line plan The department has implemented a performance-based management process designed to manage for results. This process results in
- improved reporting on our plans and priorities
- better accountability to Parliament.

The Research Branch's activities fall under the Innovating for a Sustainable Future business line, along with that of the Prairie Farm Rehabilitation Administration and the Environment Bureau of the Policy Branch. The directorate prepared
- the year-end report for 1998–1999 on the results of the Business Line Plan
- the Business Line Plan for 1999–2000.

New tools for ethical research Responsible conduct in research is important to Agriculture and Agri-Food Canada, its employees, and the public. The technologies supporting Canada's agri-food sector are becoming more complex. Thus the impacts of research applications, both positive and negative, should be considered. These impacts may be
- social
- environment
- economical.

The directorate is developing a handbook for responsible conduct in research. It also represents the branch and department on an interdepartmental working group that is currently developing a code of best practices for science, related to
- conduct
- management
- use.

This work will generate ethical guidelines that identify values and best practices, as well as consolidate current ethical frameworks in a manner that recognizes today's social values and concerns.

Representation in Federal Partners in Technology Transfer The Government of Canada has the largest innovation team in the country, with more than 25 000 people working in its research institutions. The Federal Partners in Technology Transfer unites science-based departments and agencies on issues related to the transfer of technology. RPC represents the Research Branch and ensures that research centres are kept abreast of new practices in the areas of
- technology transfer
- management of intellectual property.

Enhanced awareness of tax credits The branch's collaborative clients can claim from Revenue Canada scientific research and experimental tax credits of up to 35% of their contribution to qualifying collaborative research agreements. The directorate works

- with Revenue Canada, to ensure that they are aware of the branch's collaborative activities
- with the branch's centres, to make them fully aware of this program
- with members of the agri-food sector, to help them maximize their access to these tax credits.

Corporate sponsorship of R&D Impact Network
The directorate represents the branch as a corporate sponsor of the R&D Impact Network, currently managed by the Conference Board of Canada. The network recognizes the growing need
- to refine and adapt tools for measuring the social and economic impacts of R&D
- to foster the exchange of best practices among government, industry, and academia.

The directorate can assist the branch in developing the tools needed to measure the impact of its own R&D. It represents the branch on an interdepartmental working group that is currently developing a set of best practices. Its purpose is to measure the impact of science and technology
- carried out in federal labs
- on the development of science policy.

New research initiatives for biotechnology The directorate represented the Research Branch in developing the new Canadian Biotechnology Strategy, announced by the federal government in August 1998. It also assisted in developing new research initiatives emerging from priorities of the strategy.

Consultations with universities The directorate helped organize and coordinate a meeting on 11 August 1998 in Ottawa with the Minister and representatives of Canadian universities having a stake in agri-food research. As part of the Minister's ongoing consultations with the agri-food sector, the meeting addressed the question of how to obtain the best value from the research resources available across the country. The university leaders spoke about
- their current outlook on research
- strategies being adopted
- issues currently affecting university–government collaboration
- opportunities to improve collaboration and resource use in the future.

Briefing for testimony to standing committees
Standing committees are empowered by Parliament to study and report on all matters relating to the mandate, management, and operation of government departments, including examination of main estimates. Senior civil servants are called before these committees as witnesses, to clarify and explain issues relating to these matters. In the past year, the Science Policy and Planning Division has prepared briefing material for
- the Minister of Agriculture and Agri-Food and the Assistant Deputy Minister of the Research Branch, to appear before the Standing Committee on Agriculture and Agri-Food
- the Assistant Deputy Minister, to appear before the Standing Committee on Environment and Sustainable Development.

Participation in tetrapartite meetings Each year in June the heads of agri-food science meet to exchange viewpoints and debate specific issues of science and technology facing
- Canada
- United States
- France
- England.

Papers on specific topics are presented by each country, and formal responses are developed for debate. RPC coordinates preparation for these meetings. This year the directorate hosted the meeting in Quebec City.

Support for interdepartmental cooperation The directorate carries out support activities for the Assistant Deputy Ministers for science. It also provides input on S&T achievements within the public service. In support of a memorandum of understanding on research for sustainable development involving five natural resources departments, the directorate
- participated in an Internet working group and workshop
- planned involvement on joint promotional opportunities.

Implementation of Science Horizons The directorate helps to implement the Science Horizons program in agri-food. Its aim is to provide internships to young Canadians who have studied in agri-science related fields. This program, run in partnership with private-sector companies and nongovernment organizations, had $1.1 million in federal funds available for matching in 1998–1999. In December 1998 the Prime Minister announced that the Youth Employment Strategy, of which science is a part, is being made permanent.

Coordination of Year-2000 activities Information Management Services coordinates the branch's Year-2000 activities. Their work has included
- making presentations on the Year-2000 issues to most centres
- carrying out inventories of applications, infrastructure, telecommunications, and embedded systems
- developing an Intranet site to provide information to staff on the status of Year-2000 compliancy of laboratory equipment and building systems
- carrying out testing and remediation of all critical systems.

Development of Environmental Management Program Since 1 April 1998, the directorate has participated in developing the Environmental Management System (EMS). This system is a framework for managing, monitoring, and reporting on environmental performance. Implementing the EMS is a joint initiative between Agriculture and Agri-Food Canada and the Office of the Commissioner of the Environment and Sustainable Development of the Office of the Auditor General.

The first step in developing the EMS is to present a status report on the department's environmental management in the form of an environmental management review. To prepare this review
- workshops were provided to the responsible centres to facilitate the collection of the data
- all centres have completed their reviews and have submitted them to branch headquarters
- the directorate is currently consolidating these submissions.

The directorate will then prepare an environmental agenda for the branch. The environmental agenda will address
- specific branch objectives
- short- and long-term targets
- proposed actions to meet the objectives and targets.

Implementation of Storage Tank Management Program On 1 April 1998, the directorate became responsible for implementing the Storage Tank Management Program. This program
- includes the Storage Tank Registration System (registration is mandatory under regulations of the *Canadian Environmental Protection Act*)
- provides information for the annual report to Environment Canada
- helps to meet guidelines of the Council of Canadian Ministers of the Environment (CCME).

To be compliant under CCME guidelines by 31 December 2000, the Research Branch must
- fully assess the state of its storage tanks
- undertake appropriate remedial action.

Research Branch owns 165 storage tanks. Upgrade costs have been estimated at $2.3 million. Proper arrangements for upgrading have been made through the directorate, and remedial action is under way.

Provision of research information The Inventory of Canadian Agri-Food Research (ICAR) provides information from both the public and private sector on more than 2400 agri-food research projects in progress. ICAR continues to be available on
- Agriculture and Agri-Food Canada's Electronic Information Service via Internet (http://www.agr.ca/icar/icarhome.html)
- U.S. Department of Agriculture's Current Research Information System web site (http://cristel.nal.usda.gov:8080/)
- the international on-line service *Dialog.*

The ICAR office, staffed by the directorate, provided information
- to produce returns-on-investment studies and national strategies
- to look at gaps in the area of environmental issues around agriculture research
- as background for the forage–pasture program in western Canada.

For example, the Ottawa Life Sciences Council used information from ICAR to assist in establishing their Advanced Agricultural Technology Strategy. As well, Goodfellow Agricola Consultants, Inc., used information from ICAR in developing the Royal Bank Growth Corporation's initiative for company creation in the agri-science sector.

The Windows-based ICAR Update Program developed in 1997 was updated to include a reporting feature. Work continues on a new Internet site that would allow users to query the ICAR database directly for information from the current (1998) and historical years (1986–1997) of ICAR.

Enhancement of the Study Management System The Study Management System (SMS) is an integrated approach to managing information across the branch. This system helps in selecting research studies based on

- probability of success
- payback to the nation
- cost of conducting the research.

It also collects information, tracking about 300 studies in progress within the branch, from inception to the final deliverables. More enhancements have been added to the system with the latest version, 2.0, including

- 32-bit environment
- context-sensitive help for the study evaluation module
- SMS Express, a quick and easy method of entering new studies
- revised classification screens for information from the Inventory of Canadian Agri-Food Research
- correction of past problems.

Both the demonstration and full working versions have been sold. They can be purchased by clients from outside the department.

New capabilities of the Microcomputerized Management Information Processing System The following modules of the Microcomputerized Management Information Processing System (MMIPS) are in use throughout the Research Branch:

- equipment inventory
- order–expenditure processing
- resource planning.

Capabilities added in 1998 include

- MMIPS equipment data conversion for Saturn
- Corporate Services Branch equipment and real property data conversion for Saturn.

The MMIPS equipment module is now Year-2000-compliant. The order–expenditure module will be Year-2000- compliant when the next update is released in 1999.

New direction toward strategic promotion The newly named Strategic Promotion Team began a process to enhance activities for corporate promotion. Results included

- coalition with other federal science departments to enhance the value of science for Canadians
- development of an action plan for science and technology communications
- initiation of a marketing strategy that refocuses the branch's successes within the framework of the government's priorities, in order to make research more relevant to those making decisions about funding.

Promotion of sustainable development in agriculture The branch cooperated with other science departments to take advantage of shared audiences and common communications goals. Our successful collaborations included

- a new media outreach publication, *Science Teasers*, launched during Science Technology Week in September 1998
- a new series of television videos for the Discovery channel aired between November 1998 and June 1999 on five themes—climate change, health, biodiversity, toxins in air and water, and public participation in science
- a communications workshop and booths staffed at the Science Managers' Forum in December 1998, to encourage more support within the science community for enhancing public awareness of science
- a pilot for a multi-media project on agriculture and the environment, prepared in March 1999; the final product will be shown at public venues to enhance people's awareness of the value of science.

Promotion of collaborative opportunities through corporate publishing The branch continued to use several tools at headquarters to promote technology transfer and collaborative arrangements to the agri-food sector. These tools include

- *AGvance,* our corporate industry newsletter, which this year highlighted research opportunities that support the greenhouse industry, as well as research to optimize agriculture in cold climates
- *Directory of Research 1997–1998*, describing the facilities, expertise, and achievements of the branch's 18 research centres across Canada and posted on-line in April 1998.
- Research Branch home page, redesigned in June 1998 to focus on the differing needs of the branch's five distinct audiences: scientists, industry, business, the media, and youth.

Production of two key reports The directorate produced two key publications in support of Branch priorities:

- *Health of our Air* is the second in a three-part series co-produced with help from the branch's research partners. Released in March 1999, it presents the results of Green Plan research. It explains to the farming sector and environmental groups how agriculture influences the quality of our air and can contribute to reducing greenhouse-gas emissions.
- *Investing in Life's Basic Building Blocks* is an internal report released in August 1998, which positions the branch as a player in genomic research. Its aim is to influence decision-makers concerned with funding of biotechnology research in Canada.

Participation in National Public Service Week The directorate coordinated the branch's participation in celebrations during Public Service Week. The focus was on involving the public in honoring the achievements of our staff. RPC

- provided a branch representative for the departmental planning committee
- provided copy-writing and poster design for advertising the events internally and to the public
- participated in planning an open house hosted by the Eastern Cereal and Oilseed Research Centre on the Central Experimental Farm in Ottawa
- staffed a table selling branch publications at the open house
- designed and staffed a welcoming kiosk at the open house, highlighting the history of the branch.

Selection for university grants The directorate conducted the annual selection process for grants to universities through the research partnership support program sponsored by the Natural Sciences and Engineering Research Council.

Support for international multilateral organizations
The directorate provided support on behalf of the branch or department for the

- United Nations Food and Agriculture Organization
- Centre for Agriculture and Biosciences International
- Inter-American Institute for Cooperation in Agriculture
- North American Plant Protection Organization
- Organization for Economic Cooperation and Development
- Asia Pacific Economic Cooperation.

Support for international agreements and activities
The directorate negotiated or provided support to the government or to the agricultural sector nationally on science and technology issues for the

- International Maize and Wheat Improvement Centre
- Convention on Biological Diversity and its Biosafety Protocol
- International Undertaking on Plant Genetic Resources
- World Food Security Global Plan of Action
- Working Group on Agriculture and Agri-Food of the Intergovernmental Economic Commission with Russia
- Agricultural interests from Ukraine, Argentina, Chile, Philippines, Viet Nam, Germany, France, China, Japan, and South Africa
- Government of Canada Scientific and Technological Cooperation agreements with Germany, Japan, France, and the European Union
- the Vice-Minister for Science and Technology Commission, visiting the branch from China.

Support for federal branches, departments, and agencies The directorate provided scientific advice and support on

- biodiversity, endangered species legislation, and the Global Environment Facility
- Agri-Food Trade 2000 Fund, international markets and trade, malting barley, and

Functional Food Science in Europe
- biotechnology strategies and coordination
- Going Global.

Offers to visiting fellows The Visiting Fellowships in Canadian Government Laboratories Program, sponsored by the Natural Sciences and Engineering Research Council (NSERC), provides promising young scientists with an opportunity to work with research leaders in federal government laboratories across the country. The Department usually has 70 to 90 visiting fellows working in its laboratories at any one time, at an annual cost of about $2.25 million. At mid-year, 30 offers to new fellows had been issued. Program information and application forms are available on the NSERC website at www.nserc.ca.

Major Capital update Major Capital funds are used for Major Construction and for Health and Safety projects. They are managed as part of a five year plan, which is updated annually. Projects are also prioritized each year to ensure proper funding to the most important projects of AAFC. In 1997–1998, 61 projects were in the plan and 12 were identified as being of the highest priority.

The level of funding in 1997–1998 was $33.4 million and was fully used. Of the total amount, $2.9 million was invested in Health and Safety.

Demographic and statistical report Demographic analysis provides a statistical overview of the population as of 1 April 1998 for Research Branch. It contains sections on
- Eastern Region
- Western Region
- Research Planning and Coordination Directorate
- Human Resources Division
- population
- demographics
- diversity
- succession planning.

An analysis of the incentive packages taken by Research Branch employees was carried out. Also, a study of characteristics of Branch employees and employment was completed.

Pilot project for hiring A pilot project was initiated to help in hiring term employees under collaborative research agreements between government and private industries. The 2-year project, which extends until July 1999, is being carried out at
- Lethbridge Research Centre
- Horticulture Research and Development Centre (Saint-Jean-sur-Richelieu).

Employment Equity Plan The Research Branch Employment Equity Plan is a commitment to recruiting, developing, and promoting meritorious individuals from the four designated groups:
- people with disabilities
- visible minorities
- Aboriginal peoples
- women.

Human Resources Plan The Research Branch Human Resources Plan
- identifies and responds to issues
- charts new policies, systems, and programs that assure effective human resources management under changing conditions linked to Agriculture and Agri-Food Canada's business plan.

Coordination of Universal Classification System The division has coordinated the activities related to adopting a new set of values that focuses on work outputs and results by expanding occupational groups. This new focus requires reworking job descriptions through
- writing
- evaluation
- conversion.

Support for science and technology Advisors assist the science and technology community by
- facilitating national consultation workshops
- leading the Interdepartmental Committee on Recruitment programs for students (Federal Student Work Experience Program and Cooperative Education Program) and implementing the various projects that result from this initiative.

Participation in the Science & Technology Interdepartmental Committee The division assists in developing and implementing policies and cost-effective tools that science managers can use to align their organizations and their scientific staff to resolve long-standing issues of managing human resources.

Agriculture and Agri-Food Canada Publications

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Mandate

The Atlantic Cool Climate Crop Research Centre (ACCCRC) serves as the national centre of expertise for the development of crop-production systems for cool summer conditions. It develops technologies for the production of

- animal feed crops
- vegetables, especially on peat soils
- small native fruits.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $1.6 million through their operating budget and $0.8 million from the Matching Investment Initiative. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

The centre is located on 64 ha of land in St. John's and includes
- offices
- laboratories
- greenhouses
- numerous farm buildings.

Land at the St. John's site is used for trials with forages, cereals, vegetables, small fruit, and integrated pest management.

The provincial agriculture building is linked to the centre's office–laboratory complex, reflecting the cooperation between the two levels of government. Greenhouse facilities of the Canadian Food Inspection Agency are located at the centre. The centre also rents office space to the
- Farm Credit Corporation
- Newfoundland & Labrador Federation of Agriculture
- the Newfoundland and Labrador Horticulture Council
- Newfoundland & Labrador Livestock Council.

The Avondale field site is located 67 km from the centre. It provides additional field research capabilities and is used for
- blueberry and lingonberry trials
- field evaluation of the resistance of potato stocks to wart disease and potato cyst nematode.

Achievements

- *Staff awards and honors*
- *MII - New forage-production system for peat land*
- *Lingonberry cultivar trial*
- *Undersowing to reduce cabbage root maggot*
- *Cranberry insect pests and pollination*
- *Evaluation of red clover decline*
- *Test of early-spring perennial forage legume*
- *Evaluation of persistent forage legume*
- *Comparison of alfalfa-cutting systems*
- *Grain production*
- *New yield model for precision farming*
- *Barley genome mapping project*

Staff awards and honors Kenneth Proudfoot, former scientist at the centre, won an Agcellence Award for his contribution to Newfoundland agriculture. During his career, he produced nine varieties of potatoes and two of rutabaga. An estimated 70% of potatoes grown in Newfoundland originate from his program.

All members of the research centre were presented with an Agcellence Award by the director, recognizing their long-term commitment to superior public relations in the form of the Annual Farm Field Day, the centre's open house. In 1998, attendance was 10 288, an all-time high for the centre and the Research Branch.

Juanita Coady, an M.Sc. student at the centre, won the student presentation competition at the Acadian Entomological Society annual meeting.

MII - New forage-production system for peat land
A new forage-production system for peat soils is helping to bring feed costs down for one Newfoundland dairy farm. The farm's huge land base has not been fully utilized, mainly for lack of a practical forage-harvesting system for peat soils. A 3-year (1996–1999) Matching Investment Initiative agreement was signed with Haricot Farms Ltd., to explore solutions to problems with forage production on peat soils. The goal was to
- develop a system that used as much of the farm's existing forage equipment as possible
- integrate peat-land forage production into the farm operation with minimal expense.

To develop this system, researchers looked at

- drainage
- methods to establish forage
- machinery modifications that would permit conventional forage equipment to venture successfully onto the peat land site.

During the course of the project

- dual wheels were added to the farm tractor and the round baler
- the crop was cut using a 1.8-m disk mower
- the crop was baled using a standard round baler
- a trailer fitted with a boom loader and a standard bale grapple carried three bales at once off the field (large flotation tires on the trailer allow repeated trips over the peat sod)
- bales were loaded onto a larger wagon for transport to the storage area.

These practices and equipment proved successful in harvesting the crop on peat land.

The peat-land crop is cut after the mineral-soil crop is harvested. The harvested crop from the 3-ha test site

- totaled 36 round bales (about 3.5 tonnes of dry matter per hectare) in 1997
- totaled 49 round bales (5 tonnes of dry matter per hectare) in 1998
- contained about 12% crude protein
- has been used to feed dry cows through the winter.

Lingonberry cultivar trial In 1997, researchers carried out a field trial at the Avondale substation to determine the suitability of various lingonberry cultivars for commercial production in Newfoundland. The following cultivars were included in the trial:

- Erntekrone
- Erntesegen
- Erntedank
- Splendor
- Regal
- Sussi
- Sanna.

Establishment and growth during the 1997 season was excellent. Nearly 100% of the plants survived the 1997–1998 winter season.

In 1998, nitrogen–phosphorus–potassium fertilizer treatments were given to these cultivars to evaluate their effect on growth and production. Compared with the untreated control, plants that received nitrogen at a rate of 60 kg/ha produced

- darker green foliage
- larger berries
- higher yields of ripe fruit yields.

Phosphorus and potassium did not produce these effects. However, these results should be considered preliminary, because the effects of applying these nutrients to recently established plants may not be readily apparent at this time.

The best-performing cultivars, producing the largest berries and highest yields (double that of the others), were

- Erntekrone
- Erntesegen.

Undersowing to reduce cabbage root maggot
Rutabaga is an important crop in Newfoundland and in some other areas of Canada. There are few effective options for controlling second-generation cabbage root maggot on this crop.

As part of an M.Sc. project, the effects of undersowing rutabaga with white clover on cabbage root maggot populations were investigated. Rutabaga undersown with clover had 70% fewer root maggot eggs than rutabaga grown in bare soil. Despite this promising result, rutabaga from both plots was largely unmarketable.

A rutabaga cultivar highly susceptible to root maggot damage was used in the study. Future plans include testing root-maggot-tolerant cultivars developed at the centre.

Cranberry insect pests and pollination The development of a cranberry industry in Newfoundland has a strong potential for success. As cranberry has never been cultivated locally, Newfoundland may be free from some of the insect pests present in other areas. However, many of the serious pests in other parts of Canada are native to North America and originally invaded commercial plantings from wild cranberry stands.

This study involved

- monitoring a number of areas with large

populations of wild cranberries for insect pests
- investigating pollination by native bee species when the cranberry flowers were in bloom.

The cranberry fruitworm was the only major pest of cranberry detected. The caterpillars of this insect feed inside the developing berries and can cause extensive losses. Large numbers of native bees were active on cranberry flowers on warm, sunny days during the bloom period. Most of these bees were

- bumblebees
- andrenid bees.

From 60 to 100% of the pollen carried by these bees during bloom was from wild cranberry.

This study was funded under the Newfoundland Safety Nets program and was done in collaboration with

- Memorial University
- Newfoundland Department of Forest Resources and Agrifoods.

Evaluation of red clover decline The decline of red clover is a serious problem for the forage industry in Newfoundland. This decline may be partly the result of damage caused by root-feeding weevils. Evaluations of this damage have shown a rapid increase in *Sitona flavescens* during the growing season, followed by

- winterkill
- increasing weevil infestations in the remaining red clover stand the following year.

Test of early-spring perennial forage legume An Estonian cultivar of *Galega orientalis* Lam. has shown excellent persistence compared with six commercial varieties of four other legume species. Forage galega

- produces dry-matter yields slightly less than alfalfa in forage production years but much better than other legume species because of better persistence
- is ready for first-cut harvest about 2 weeks ahead of alfalfa in eastern Newfoundland.

Evaluation of persistent forage legume When grown on low-fertility (pH 5) beach soils, old stand beach pea *Lathyrus maritimus* Bigel. has

- good first-cut yields of forage dry matter (up to 4 t/ha)
- excellent regrowth, producing up to 3 tonnes of dry matter per hectare in the fall cut.

Once established on agricultural soils, this perennial legume crop is

- very aggressive
- able to out-compete dandelions without any weed control measures
- very persistent under severe icing conditions.

This quality forage crop might be the answer to eastern Canada's search for an icing-tolerant forage legume crop.

Comparison of alfalfa-cutting systems Alfalfa maintains a viable stand for about four production years in a one-cut system at St. John's. However, total yield is greater in a two-cut system, with a viable stand for three production years. By waiting at least 500 growing degree days (5°C base) between the first and second cuts in this system, there are increases in

- stand persistence
- yield.

Grain production Five years of on-farm adaptive research into small grain production in Newfoundland has been completed. Barley is the grain species found to have the most potential for local dairy farmers. Early planting of barley

- results in the highest yields
- carries associated climatic risk.

Some local farmers, already self-sufficient in forage production, are now committing relatively large areas of land to the production of

- barley
- winter wheat.

New yield model for precision farming Researchers are collaborating with five commercial farms across the province to study the effect of geophysical properties on yields of

- forage
- barley
- winter wheat.

A simple yield model has been derived for one site. It relates soil pH to barley yields, showing the effects of applying lime. Continued analysis of soil and yield samples from these sites may provide information needed to improve local farm management.

Barley genome mapping project The grain-production group at the centre was involved in the Canadian component of the North American Barley Genome Mapping Project. This project is a large collaborative effort of groups throughout Canada, including

- universities
- Agriculture and Agri-Food Canada research centres
- private companies.

Researchers statistically analyzed disease-rating scores that had been recorded in 30 environments in North America for the Harrington–TR306 barley mapping population. For 15 quantitative trait loci (QTL) that affect resistance to five common barley diseases, this analysis was used to determine the

- genomic position
- effect.

The analysis of data collected on field trials conducted
in western Canada in 1996 and 1997 was also used to confirm the presence of a QTL on the "plus" arm of chromosome 7(5H), which affects

- grain yield
- plant height
- lodging severity.

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Mandate

The Crops and Livestock Research Centre (CLRC) has a mandate to conduct research on sustainable production systems, with emphasis on potatoes. Research is divided between two programs:

- potato
- feed and livestock.

The centre conducts research on

- management, protection, and nutrition of potatoes
- cultivar and management technologies to improve cereal and forage crops for livestock feed
- soil management and conservation
- swine and beef nutrition.

Resources

The research centre is located at the main office–laboratory complex at the Home Farm (65 ha) in Charlottetown, P.E.I. In 1997–1998, when the achievements presented in this report were completed, the centre spent $7.2 million through their operating budget, $1.8 million from the Matching Investment Initiative, and $104 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services. The facility also accommodates the staff of the

- Agriculture Division of the Prince Edward Island Department of Agriculture, and Forestry
- Atlantic regional and Prince Edward Island district offices of Agriculture and Agri-Food Canada, Market and Industry Services Branch.

The research centre operates three other properties:

- Nappan Research Farm, N.S. (240 ha), which conducts most of the centre's beef research, along with some work on forage and soils. The farm has 16 full-time staff and one full-time equivalent associated with MII-funded programs, including three scientific staff. Its facilities at Nappan are shared with the regional extension offices of the Nova Scotia Department of Agriculture and Marketing and the Maritime Beef Test Centre.
- Harrington Research Farm, P.E.I. (300 ha), which carries about 90% of the centre's field studies in cereals, forages, potatoes, and soil tillage and conservation
- Upton Farm, P.E.I. (111 ha), where some of the centre's forage research is conducted.

Three of the centre's staff, including two scientific staff involved with soils research, are located on the campus of the Nova Scotia Agricultural College, Truro, N.S.

Achievements

- *Staff awards and honors*
- *MII - Improved soil conservation for potato*
- *Improved adaptation to grazing*
- *Protein supplement in cow diet*
- *Improved silage with crop maceration*
- *Higher-yielding chicory mixtures*
- *Alternative grass species*
- *Improved soil characteristics by mulching potato*
- *New red clover cultivar*
- *Control of field mint with pre-harvest glyphosate*
- *Herbicide tolerance in corn*
- *Soil amendment with organic wastes*
- *Survey of manure application*
- *Evaluation of biocontrol for potato beetle*
- *Better planting methods for potato seed*
- *Fertilizer rates to control Verticillium wilt in potato*
- *Refined control of brown-heart in rutabaga*
- *Assessment of pasture renovation*
- *Review of soil quality*

- ***Assessment of potential for soil carbon storage***
- ***Survey of beef quality***
- ***Improved nutrition of bulls***
- ***New silage inoculants***
- ***New measure of snowmelt erosion***
- ***Compost as good growth medium***
- ***Assessment of subsoiling prior to potato planting***
- ***Evaluation of irrigating lowbush blueberries***
- ***Assessment of aeration with manure application***
- ***Land-use assessment***
- ***Survey of aphid populations***
- ***Optimal Russet Burbank yields***
- ***Optimal Island Sunshine yields***

Staff awards and honors The centre participated in the project "Development of New Potato Clones for Environmental and Economical Sustainability in the Northeast", which was awarded the U.S. Directors' Award for regional research excellence.

MII - Improved soil conservation for potato A project involving producers, federal scientists, and provincial extension workers was conducted under the Matching Investment Initiative (MII). The team found that residue management (the practice of retaining dead plant material at or near the soil surface) benefited producers that used

- 2-year grain–potato rotations
- 3-year grain–forage–potato rotations.

It was also found that residue management

- reduced soil erosion in 2-year rotations of grain–potatoes by as much as 50%
- reduced soil erosion in 3-year rotations of grain–forage–potatoes by more than 90%
- improved potato yields by 5–10% in the 3-year rotations
- reduced tillage costs by $60–$160/ha.

Improved adaptation to grazing A joint Agriculture and Agri-Food Canada–Nova Scotia Agricultural College project has shown that animal behavior at turnout to pasture is important in determining the performance of cattle at this time. It takes several weeks for cattle to settle to a productive grazing routine. During this time

- intake is reduced
- weight loss can occur.

To minimize the negative impact of turnout, cattle should be

- turned out in advance of rapid grass growth
- presented with supplemental feeds.

Protein supplement in cow diet Providing a protein supplement to silage-based diets for winter-calving beef cows

- increased rates of gain in the calves
- improved reproductive performance of the cows.

Protein supplementation is recommended only for cows in good body condition. A less-degradable protein source, such as corn gluten meal, is more effective than a more-degradable protein source, such as soybean meal.

Improved silage with crop maceration Researchers collaborated with colleagues from the Soils and Crops Research and Development Centre, Ste. Foy, Que., to examine the effects of crop maceration on silage feeding value. Studies at Nappan showed that crop maceration improved silage fermentation. This improvement in turn led to benefits for ruminants fed the macerated silages, including

- increased intake of the silage
- increased digestibility of the silage.

Reasons for varying responses to maceration are still under study, but are known to include

- degree of wilting
- maturity of the crop.

Higher-yielding chicory mixtures Forage chicory cultivar Grasslands Puna had the highest yields when grown in mixtures with

- orchardgrass–white clover
- timothy–alfalfa
- timothy–red clover.

Including chicory in grass–legume swards

- improved the seasonal distribution of herbage

- increased herbage production in late season.

The winterhardiness of chicory was acceptable, as chicory persisted for three production years.

Alternative grass species Timothy is the grass most commonly grown for forage in eastern Canada. Alternative forage species that produce comparable yields include
- Kentucky bluegrass
- red fescue.

Seasonal distribution of dry matter was particularly favorable for bluegrass, as about 60% of dry matter was produced after the first cut in late summer.

Improved soil characteristics by mulching potato Researchers collaborated with personnel from the Biological Engineering Department, DalTech, to study the effects of straw-mulching potatoes. The study was conducted on erosion plots and a monitored agricultural watershed in Prince Edward Island. They found that the mulch
- reduced soil loss by 50% (cool- and warm-season average)
- increased soil water content by a significant 5.3%
- increased soil penetration resistance by 15%.

Year-round measurement of nutrient runoff from three sub-catchments showed an average nitrogen content of 6.1 ppm, which is well below the 10-ppm safety level set by the province.

On the other hand, the mulch
- reduced tuber yields by almost 10%
- reduced marketable yield by 25% (total yield suffered a 5% loss to field mice harbored by the straw).

New red clover cultivar The centre has released a new red clover cultivar to the industry. This new cultivar, AC Christie,
- is a high-yielding forage
- shows increased resistance to root rot, resulting in increased persistence over years.

Control of field mint with pre-harvest glyphosate Studies conducted in Prince Edward Island and Nova Scotia showed that glyphosate applied before harvest in barley and wheat gave control the next year of
- field mint
- quackgrass.

Pre-harvest timing was superior to post-harvest timing for controlling field mint.

Herbicide tolerance in corn Studies conducted in Prince Edward Island and Nova Scotia showed that several corn hybrids of low corn heat unit rating were tolerant to the herbicide DPX-79406. Hybrids that displayed good tolerance to the recommended rate of application are
- DK220
- DK302
- Pickseed 2244
- Pickseed 2299
- Pioneer 3921
- Pioneer 3967
- Pioneer 3979
- Pioneer 3947
- Pioneer 3962
- Bishop 30-30
- NO565
- G-4011.

Soil amendment with organic wastes Researchers compared the residual effects of applying two different organic sources, along with various rates of nitrogen fertilizer, for two years to annual ryegrass. The organic sources were
- source-separated municipal solid waste (SSMSW) compost
- beef manure.

After the first year it was found that
- ryegrass yields were similar for the two organic nutrient sources
- plots that received SSMSW compost had higher numbers of worms, especially immature worms, than plots that received manure.

Survey of manure application Manure is uneconomical to transport long distances, so most farmers spread manure on land close to their livestock-handling units. This practice can lead to a buildup of nutrients. A survey of when and where Nova Scotia and New Brunswick beef farmers surface-applied manure showed that
- about 80% of manure is applied to pasture (20%) and hayland (60%)
- equal proportions of manure were spread in early

spring, summer, early fall, and late fall.

Three experiments on repeated applications of manure showed that soil nitrogen content at the Nappan site

- tended to rise with increased addition of manure
- did not differ when manure was applied at different times.

Evaulation of biocontrol for potato beetle Researchers applied entomopathogenic nematodes *Steinernema carpocapsae* to Colorado beetle

- larvae
- pupae
- adults.

This treatment resulted in 100% mortality of the beetle under laboratory conditions. Nematodes also reduced the number of late-season adults by 31% at one field site in New Brunswick during 1 year of the experiment.

To achieve consistent control of the Colorado potato beetle, further investigations are needed into the benefits of

- repeated applications of nematodes
- improved delivery systems.

Better planting methods for potato seed Results from a recent study determined that

- planting small whole seed generally resulted in better yields for several varieties than planting 28-day pre-cut seed
- planting 14-day pre-cut seeds and seeds cut at planting had more intermediate effects
- use of post-harvest fungicide (thiabendazole) was generally beneficial, except when silver scurf was prevalent.

Fertilizer rates to control Verticillium wilt in potato Researchers studied the effects of changing the rate (half or double the recommended rate) at which nitrogen and phosphorus are applied at planting. They found that the different rates do not

- consistently reduce levels of *Verticillium albo-atrum* or *V. dahliae*
- increase tuber yields for cultivars susceptible to both pathogens.

Refined control of brown-heart in rutabaga Researchers studied the application of boron to control brown-heart in rutabaga. They found that boron was best applied

- before planting
- at 28 and 42 days after seeding (foliar application).

The study also showed that the rutabaga variety most commonly grown in recent years, Thomson Laurentian, is more susceptible to brown-heart than the York variety.

These results indicate that growers must apply boron accurately and at the appropriate growth stage to provide an acceptable level of brown-heart control, especially for Thomson Laurentian.

Assessment of pasture renovation The effect of non-inversion tillage for loosening a pasture soil was assessed over several years. Tests showed that

- the loosened soil condition persisted over several years
- the loosening reduced yields, possibly because of root damage.

Review of soil quality Researchers conducted a review of soil quality to identify approaches for evaluating soil conditions in various farming systems. Based on the recognition that soil can only be assessed for a specific purpose, a useful framework to address soil quality was built on the sequence of

- soil function
- soil processes
- soil properties
- indicators.

Assessment of potential for soil carbon storage Researchers studied the effects of cultivation on soil by comparing the soils of forested sites and adjacent cultivated or forage sites in eastern Canada for

- mass of organic carbon
- mass of total nitrogen
- organic matter fractions.

They found that cultivation

- reduced the mass of organic carbon (35%) and total nitrogen (10%) in Podzolic soils
- increased organic carbon (25%) and total nitrogen (37%) in Brunisolic (Cambisol) and Gleysolic soils
- reduced (by up to 70%) the relatively large proportion (19%) of organic carbon found in the light fraction in the A horizon of forest soils
- did not greatly influence the proportion of macroorganic carbon present in the soil sand

fraction
- reduced the amount of soil microbial biomass.

They also found that using forages increased soil-stored organic carbon (55%) and nitrogen (35%) in Podzolic soils (organic carbon fractions were mainly significant in the A horizon). Overall, soils in eastern Canada have a relatively large potential to store organic matter.

Survey of beef quality A taste panel evaluated beef produced in
- the Maritimes
- Quebec
- Alberta.

Results of the assessment showed that
- there were no major differences in taste and visual preference
- potato-finished beef from the Maritimes was lighter in color than beef produced using other feed, but this had little effect on taste or visual appeal.

Improved nutrition of bulls Bulls on performance testing were fed a totally mixed ration on silage. It was found that bulls on this diet did better than predicted (based on new feeding recommendations published by the National Research Council) in
- performance
- amount eaten
- weight gain.

Compared with traditional feeding methods based on hay and a compounded pellet, the totally mixed ration on silage reduced feed costs while not impairing performance.

New silage inoculants Researchers cooperated with partners in private industry to develop several new silage inoculants. Trials were performed to determine how inoculation influenced
- fermentation patterns in silage
- animal performance.

The efficacy of silage inoculants depends on the conditions in which they are used.

New measure of snowmelt erosion Field measurements of cool-period erosion using a new approach
- produced a reliable basis for computing soil loss and deposition under potato rotations
- established an adjustment factor for the Universal Soil Loss Equation under local circumstances.

Compost as good growth medium Compost made from sawdust and liquid hog manure produced a growth medium with good
- nutrient-release characteristics
- physical properties (including good moisture retention)
- shrinkage characteristics.

The compost can be used at proportions of up to 80% of the mix.

Assessment of subsoiling prior to potato planting Researchers cooperated with producers to examine the effects of tilling to lossen the soil to the 45-cm depth (subsoiling) during the fall prior to planting potatoes. They found that
- subsoiling did not improve potato yield
- soil moisture at time of subsoiling influenced the degree of soil loosening.

Because of the high cost of subsoiling, producers are advised to limit the use of subsoiling to specific conditions, such as
- plow pans
- small areas of severe compaction.

Evaluaton of irrigating lowbush blueberries Researchers conducted a 3-year study to evaluate the benefits of irrigation to blueberry production in Nova Scotia. There were no differences in yield between irrigated and rainfed plots, partly because of
- 2 years with precipitation totals well above normal
- a large killing frost in the third year.

Early results suggest that, under low-water conditions, blueberries show great tolerance in the maintenance of
- stomatal functioning
- carbon assimilation.

Assessment of aeration with manure application Researchers examined the effects of using a soil aerater before or after spreading liquid dairy manure on hay fields. Results from 11 farm-field trials in central Nova Scotia showed that aeration did not produce significant improvement in

- nutrient conservation
- yield.

Well-managed soils with good structure do not benefit from additional aeration.

Land-use assessment An initial needs assessment related to land use in King's County, N.S., was carried out by the centre in cooperation with

- Nova Scotia Federation of Agriculture
- King's County Municipal Planning Department
- extension staff of the Nova Scotia Department of Agriculture and Marketing.

The findings of this assessment were used to

- create a database
- select an approach to collecting the missing data.

The project involved the integration and practical application of crop-sequence mapping in a Geographic Information Systems environment, using

- Thematic Mapper imagery
- updated Canada Land Inventory ratings
- soil-suitability ratings for specific crops.

Overlaid on existing land-use zoning maps, the information is used at public hearings to provide the necessary background knowledge for discussions on land-use assessment.

Survey of aphid populations The dominant aphids to land on the seed potato fields in Prince Edward Island in 1995 and 1996 were

- potato aphid
- buckthorn aphid.

These species are less efficient than the green peach aphid as vectors of

- potato virus Y
- potato leaf roll virus.

Still, their potential to infect the potato crop should not be overlooked.

Optimal Russet Burbank yields Results from a 3-year collaborative project with Ingleside Farms Inc. suggest that no difference in total yield of potato cultivar Russet Burbank can be expected

- between small whole ("B"size) or cut seed
- by increasing the rate of applying nitrogen to more than 202 kg/ha for small whole seed.

Optimal Island Sunshine yields During a 3-year collaborative project with Gerrit & Everet Loo, researchers determined that maximum tuber yields for the potato cultivar Island Sunshine were obtained when

- nitrogen was applied at a rate of 112–168 kg/ha
- seed pieces were spaced 26–30 cm apart in rows.

Seed type (cut or small whole seed of "B" size) had no effect on yield.

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Mandate

The Atlantic Food and Horticulture Research Centre (AFHRC) works with horticultural crops, developing new cultivars and technologies related to crop

- production
- adaptation
- protection
- storage
- handling
- processing.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $6.5 million through their operating budget, $2.3 million from the Matching Investment Initiative, and $59 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services. The centre encompasses 188 ha on the eastern limits of Kentville, N.S., and 74 ha at Sheffield Research Farm, located 8 km north of the centre. The laboratory–office complex at the centre houses

- the Research Branch of Agriculture and Agri-Food Canada
- the Canadian Food Inspection Agency
- the western regional staff of the Nova Scotia Department of Agriculture and Marketing.

The centre also includes the Senator Hervé J. Michaud Research Farm on 28 ha of land near Bouctouche, N.B.

Achievements

- ***Staff awards and honors***
- ***MII - New apple for pie industry***
- ***Longer shelf-life for highbush blueberries***
- ***New technique to measure blueberry pollination***
- ***Survey of red leaf disease in lowbush blueberries***
- ***Isolation of heat-resistant fungi***
- ***Blueberry drought tolerance***
- ***New container for small fruit***
- ***Blueberry firmness in storage***
- ***Improvements in freezing blueberries***
- ***New technique to measure oxidative stress in plant tissue***
- ***Tracking of temperatures during produce distribution***
- ***Microstructure and fruit quality***
- ***Advance in "clean-in-place" sanitation***
- ***New strawberry cultivar***
- ***Discovery of rust-resistant gene in raspberry***
- ***New collaborative tree-fruit production projects***
- ***New technique to assess blossom thinners***
- ***New product to improve quality of stored apples***
- ***Tools for selecting better apples***
- ***Biocontrol of orchard mites***

- *Approval of new pesticide uses*
- *Organic fertilizers for vegetable crops*
- *Good performance of municipal solid waste compost*

Staff awards and honors Dr. Willy Kalt was awarded the 1997 Progress Club Women of Excellence Award, for achievements in scientific research.

Dr. Robert Prange was elected as one of three Canadian representatives on the Council of the International Society for Horticultural Science.

MII - New apple for pie industry Northern Spy apples have been used as the standard for commercial pie production because of

- the physical characteristics of this cultivar
- the consistent quality when it comes out of the freezer.

Another cultivar of apple, Novaspy, developed at the centre, has advantages over the Northern Spy because

- it matures earlier
- has a more consistent yield every year
- is resistant to some apple diseases.

Projects done under the Matching Investment Initiative (MII) with a local processor have shown that pies produced with Novaspy have virtually the same properties as those made with Northern Spy and will be acceptable to the industry. This work will benefit the industry by making the apple supply more stable for the pie industry.

Longer shelf-life for highbush blueberries The highbush blueberry is destined primarily for the fresh market, as it does not freeze nor dehydrate well. Blueberry harvest in the northern hemisphere lasts from August until mid-October. Production from the southern hemisphere does not begin until late December. Therefore, there is a window of opportunity to market a fresh product if the shelf-life could be extended.

Researchers worked with a producer and a consultant to modify storage conditions for blueberries. The new method

- builds on the centre's work in controlled atmosphere storage of fruit and vegetables
- allows berries to be stored for up to 9 weeks with less than 10% fruit loss.

During October 1997, about $200 thousand of blueberries were exported to England under controlled-atmosphere conditions. This technology continues to be refined, but its benefits are clear and the industry is beginning to use it.

New technique to measure blueberry pollination Researchers have developed a new technique to measure blueberry pollination by assessing

- the amount of pollen deposited
- the proportion of stigmas pollinated.

This method showed that there was little relationship between the initial fruit set and final yield of lowbush blueberry. Thus, other factors are more important in determining blueberry yield.

Survey of red leaf disease in lowbush blueberries Nova Scotia's blueberry growers have been concerned over the incidence of red leaf disease in lowbush blueberries, caused by the fungus *Exobasidium vaccinii.* A survey showed that levels of this disease

- were generally low
- have not changed significantly in recent years in Nova Scotia
- have had little effect on blueberry yield.

Isolation of heat-resistant fungi Researchers have isolated more than 30 taxa of heat-resistant fungi from soils of commercial lowbush blueberry fields in Nova Scotia. These fungi include

- two new genera
- eight new species.

This remarkable biodiversity of heat-resistant fungi may be related to the traditional practice of pruning blueberry plants by burning the fields on a 2-year cycle.

Blueberry drought tolerance Root excavations and physiological studies showed that the lowbush blueberry is

- deep-rooted
- tolerant to low soil-moisture conditions.

Although irrigation may improve fruit size in dry years, periodic drought will likely have minimal long-term effect on the plant.

New container for small fruit Rapid cooling of small fruit following harvest and packaging is critical for

- maintaining quality
- extending shelf life.

Researchers have developed a new flat container that improves the cooling rate of blueberries and other small fruit packaged in plastic clamshell containers.

Blueberry firmness in storage Loss of firmness of fresh highbush blueberries during storage was shown to result from

- water loss
- elevated CO_2
- decay.

These findings will lead to the development of new storage technologies that will enhance the firmness and quality of this fresh fruit.

Improvements in freezing blueberries Researchers removed excess surface water from lowbush blueberries with high velocity air streams before freezing. This method

- improved the quality of frozen fruit
- reduced defrosting of equipment
- saved energy.

Researchers are also studying the effects of various aspects of the freezing process on frozen fruit quality. These aspects include

- freezing rate
- freezing temperature
- level of fluidization
- frozen storage temperature.

Results of this study will allow commercial processors to significantly improve their products.

New technique to measure oxidative stress in plant tissue Researchers have developed a better technique for measuring plant lipid peroxidation. This technique allows more-accurate measurement of oxidative stress in plant tissue. Further studies have linked the anti-oxidant capacity of fresh spinach with tolerance to stress in storage.

Research shows antioxidant activity

- can be used as an indicator of environmental effects on plant health and quality
- gives new insights into how quality is retained in fruits and vegetables during storage.

Tracking of temperatures during produce distribution Researchers tracked temperatures along the grower-to-retailer distribution chain for fresh produce. Provided that proper air-flow was maintained in the refrigerated transport trailer, temperature abuse caused little damage in the produce until it reached the retailer. It is at this point of distribution that most improvements can be made in temperature control to ensure that high-quality fresh produce reaches the consumer.

Microstructure and fruit quality The centre's new food microstructure program is using electron microscopy and other techniques to study the relationship between structure and quality of various fruits. For example, it was shown that

- each of 14 apple cultivars had multidimensional attributes that contribute to its unique quality profiles
- structural changes in frozen lowbush blueberries were largely dependent on the temperature during processing and storage.

Advance in "clean-in-place" sanitation A collaborative study with Acadia University demonstrated that the continuous cycling of electricity (−0.8 to +1.2 volts) removed 40% of a model biofilm of *Enterobacter aerogenes* from a platinum electrode. This concept could have application in the control of biofilms within "clean-in-place" systems in the food-processing industry.

New strawberry cultivar The introduction in 1998 of a new strawberry cultivar, Cabot, is a major advance in developing plants that are

- disease-resistant
- large-fruited.

Cabot fruit is almost twice the size of fruit from other common cultivars. This feature benefits growers by

- reducing harvesting costs
- helping to maintain a higher wholesale price.

Discovery of rust-resistant gene in raspberry Researchers conducted genetic studies to segregate populations of raspberries for late yellow rust reaction. They have discovered that a single major gene, designated Pa, is responsible for resistance. This discovery will facilitate breeding for resistance to this important disease.

New collaborative tree-fruit production projects A number of collaborative projects involving processors, Nova Scotia Agricultural College, and the Nova Scotia Tree Fruit Research Foundation have been initiated to examine the effects of

- management practices on commercial packout and repeat bloom
- irrigation, fertigation, and mulch on young orchards on dwarf rootstocks
- deep soil modification on new orchard performance
- tissue culture propagation on new apple rootstock performance
- optimum care on performance of new production systems and cultivars.

New technique to assess blossom thinners Using blossom thinners is the most effective way to increase the size of apple fruit. The centre developed a new technique for assessing blossom thinners and tested it over 3 years. Results showed that the most effective thinning was achieved with stigmatic coatings of

- Safer Soap
- polyethylene glycol.

The most effective pollenicides were

- monobasic ammonium phosphate
- sodium chloride
- ammonium thiosulfate.

The effectiveness of these compounds must be further tested in the field. Consumer acceptance of these environmentally friendly compounds is expected to be high.

New product to improve quality of stored apples The anti-ethylene product ReTain™ has now been registered and approved for use. When applied as a preharvest spray, it improved the quality of Nova Scotia-grown apples during long-term storage.

Tools for selecting better apples Texture is a primary attribute of fresh apples. Better tools to assess texture are being provided by

- novel sensory methods to measure texture of apple cultivars
- consumer preference ratings.

These methods are now used to select cultivars that have desirable market characteristics. Further studies have shown that establishing new cultivars in the marketplace can be assisted by

- in-store taste tests
- market demonstrations.

Biocontrol of orchard mites In 1998, researchers cooperated with apple producers to introduce a biological control agent for the heavy mite infestations that occurred during this particularly dry season. The insecticide-resistant predaceous mite, *Typhlodromus pyrii*,

- provided effective control of three phytophagous (plant-eating) mite species in 17 of 25 commercial orchard blocks
- permitted producers to significantly reduce applications of chemical miticides without reducing apple yield or quality.

Approval of new pesticide uses Researchers have completed work that has led to the approval and registration of several new pesticide uses under the Pest Management Regulatory Agency's minor use program. These uses include

- *Bacillus thuringiensis* (Bt) for the control of whitemarked tussock moth in lowbush blueberries
- tribenuron-methyl for weed control in lowbush blueberry
- triclopyr for stump treatments in lowbush blueberry
- fluazifop-P for grass control in strawberry nursery production.

Organic fertilizers for vegetable crops Organic fertilizers can be used effectively in commercial vegetable production. Researchers carried out a 6-year rotational study in which plants received either

- one of several marine-based organic fertilizers
- a chemical fertilizer that delivered the same amount of nitrogen.

Yields were not the same for beans under the two treatments, but were the same for

- carrots
- cabbage.

The benefits were greater when organic fertilizers were changed in the rotation, because their nutrient profiles were complementary.

Good performance of municipal solid waste compost Municipal solid waste composts may differ markedly in their chemical and physical properties. However, when mixed with peat, they proved to be an excellent, stable medium for growing containerized woody nursery stock. Thus, the container nursery industry could be an important market for this composted waste product.

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Mandate

The Potato Research Centre (PRC) is responsible for

- breeding new potato cultivars and improving germplasm
- developing technologies for the production, handling, and management of potatoes
- protecting natural resources.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $6 million through their operating budget, $1.2 million from the Matching Investment Initiative, and $14 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services. The land base at its two locations covers 645 ha. The centre operates a potato-breeding field site at Benton Ridge, about 100 km west of Fredericton. The centre shares its office–laboratory building in Fredericton with

- Market and Industry Services Branch of Agriculture and Agri-Food Canada
- Canadian Food Inspection Agency
- head offices of the New Brunswick Department of Agriculture and Rural Development.

Achievements

- ***Staff awards and honors***
- ***MII - Irrigation and N study***
- ***Anther culture of potato***
- ***New DNA biotechnologies***
- ***Release of new potato varieties***
- ***New methods for predicting field performance***
- ***Russet Burbank clones***
- ***Resistance mechanism***
- ***Viral control by systemic insecticides***
- ***New finding for potato spindle tuber viroid***
- ***Improved technology to detect viruses***
- ***Identification of phytotoxin intermediates***
- ***Evaluation of terraces and grassed waterways***

Staff awards and honors Dr. Rudra P. Singh received an Agcellence Award for his outstanding contribution to the potato industry and the Agri-Food Sector. His leadership and innovation in the areas of biochemical and molecular methods for detecting and characterizing pathogens have been widely recognized. His results have been incorporated into potato certification programs throughout the world.

Ms. Valerie Burns received an Agcellence Award for leadership in recognition of her exemplary attitude toward her work and her willingness to share skills and knowledge. The many improvements she has introduced, such as maintaining a computerized inventory of true potato seed, increased the program's efficiency.

Dr. Henry De Jong received the Distinguished Service to New Brunswick Agriculture Award, presented by the New Brunswick Institute of Agrologists. This award recognizes his many contributions to the industry and his profession in New Brunswick.

MII - Irrigation and N study With scientists at the Potato Research Centre, McCain Foods Ltd. recently completed a supplemental irrigation × fertilizer N rate study for potatoes in northwest New Brunswick. Averaged over all sites and years, supplemental irrigation improved both total and marketable yield by about 6 t/ha. The response was not affected by variety, but was highly variable among sites for a given moisture deficit. Often, only limited yield increases were recorded for fertilizer N rates above 100 kg/ha. Potential yield in the Upper Saint John River Valley is estimated at 50 t/ha.

Anther culture of potato Researchers screened 23 diploid clones of potato anther culture response in vitro. Both diploid (24 chromosomes) and monoploid (12 chromosomes) plants were regenerated. RAPDs + randomly amplified polymorphic DNA (RAPD) analysis of anther-derived plantlets and roots revealed distorted segregation. RAPD analysis of single pollen grains was reported for the first time. Segregation of markers from the parent demonstrated the potential of this technique for generating linkage maps of monoploid tissue of potato.

New DNA biotechnologies The centre has developed three new biotechnologies for potato:

- DNA markers of parental breeding lines, used to

predict traits of quality for processing (e.g., specific gravity, chipping score, and glucose content) in potato progeny
- an improved method of potato DNA fingerprinting to identify varieties
- molecular phylogeny of *Streptomyces scabies* isolates (pathogen of potato scab disease) for studying the mechanism of phytotoxin production.

Release of new potato varieties Researchers working in the centre's breeding program have completed a 6-year evaluation of the suitability of nine new potato clones for frozen french fries. These clones were offered to the Canadian industry for a 2-year period of nonexclusive evaluation. Six companies and producer groups requested some or all of the clones. This response represents the successful launch of a faster process for commercializing new varieties.

New methods for predicting field performance Researchers have developed new methods that appear to provide potentially useful tools for estimating the field performance of the two main potato cultivars used in processing:
- Russet Burbank
- Shepody.

These simple tests, carried out 3–4 months before planting, are based on
- sprout growth
- internal sugar changes.

Russet Burbank clones Russet Burbank, a major potato cultivar used in North American processing, has been reported to vary in yield depending on the source of planting material. An examination of 11 Russet Burbank clones currently used as a source of North American nuclear material has verified that morphological and agronomic differences occur.

Resistance mechanism Several species of wild potato are highly resistant to the Colorado potato beetle or aphids, or both. Researchers conducted experiments to establish the mechanism of resistance and found that
- wild potatoes are not directly toxic to the beetle
- the resistance mechanism seems to involve chemicals (not glycoalkaloids) that reduce ingestion or deter colonization.

Insect-resistant traits will be transferred to potato. Insect-resistant potato varieties can help
- reduce the use of chemical insecticides
- control diseases transmitted by aphids.

Viral control by systemic insecticides Researchers collaborated with industry in a 3-year field study of the effects of applying systemic insecticides to soil or canopy. Such applications did not significantly reduce the spread of nonpersistent viruses in the potato crop. In particular, the popular insecticide imidacloprid was found to be
- ineffective in reducing the spread of the potato virus PVY, contrary to the expectation of Canadian growers
- effective in reducing aphid abundance on potato crop without promoting vector dispersal.

New finding for potato spindle tuber viroid The International Potato Centre has reported that the potato spindle tuber viroid (PSTVd) is spread in very high proportion by aphids from plants doubly infected with PSTVd and leafroll. In contrast, PRC researchers found that the spread of disease from plants doubly infected in this way is
- less than 7% for PSTVd
- 100% for leafroll.

Thus there is no cause for alarm in Canada, where PSTVd has been eradicated from seed-potato production.

Improved technology to detect viruses Further improvements have been made in the technology to detect viruses based on the development of the polymerase chain reaction (PCR). Improvements involve using citric acid to neutralize the effects of polyphenols in the tuber extracts, thus increasing
- the reliability of viral detection by PCR
- the design and use of new PCR primer pairs for the exclusive identification of the necrotic strain of potato virus Y (PVY^n).

These technologies enable the reliable detection of PVY^n in tubers intended for seed export soon after harvest.

Identification of phytotoxin intermediates Common scab in potato has been connected to phytotoxins that are produced by bacteria. If scientists could identify the biosynthetic precursors of these phytotoxins, they might hope to control production of the phytotoxins and the spread of the disease itself. To this end, PRC researchers have identified unique nitroanthralic acids that may be the precursors of the phytotoxins associated with common scab in potato.

Evaluation of terraces and grassed waterways

Researchers carried out a field evaluation of

- variable-grade diversions
- grassed waterways.

The evaluation showed that, under potatoes, these structures

- reduced runoff by as much as 150 mm of rainfall equivalent, thereby increasing available moisture for potato growth
- reduced soil losses from 20 t/ha per year to 1 t/ha per year.

Terracing also reduces the chance that the basin will cause flooding.

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Mandate

The Soils and Crops Research and Development Centre (SCRDC) conducts research to

- provide technology and expertise in the area of integrated soil and crop management
- promote the protection of soil, water, and air quality
- create new forage products and new technologies that assist in producing, managing, harvesting, preserving, and diversifying these products
- develop techniques for producing and using field crops in the Canadian mid-North.

Resources

The centre is located near Laval University, which has one of the largest agriculture faculties in Canada. In 1997–1998, when the achievements presented in this report were completed, the centre spent $7.1 million through their operating budget, $2.7 million from the Matching Investment Initiative, $48 thousand from other special programs, and $108 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services. The centre operates two farms:

- a 75-ha test plot at Saint-David-de-l'Auberivière, about 15 km south of Quebec City, where plant production research is carried out
- the 145-ha Normandin Research Farm, located in the North-Western part of the Lac-Saint-Jean area.

Achievements

- ***MII - Development of crop processor module for forage harvesters***
- ***Assessment of fungus on Timothy***
- ***Study of gas emissions from manure***
- ***Monitoring the oxidation of soil organic matter***
- ***Improved soil organic matter with manure application***
- ***Soil conservation with paper de-inking residues***
- ***Reduced tillage in spring canola production***
- ***Comparison of broad bean cultivars***
- ***Intensive forage conditioning***
- ***New alfalfa cultivar***
- ***New timothy cultivar***
- ***Study of freezing tolerance of forage plants***
- ***Micronization study***
- ***Soil moisture estimates using remote sensing***
- ***Improved soil-moisture predictions***
- ***Evaluation of weeds' effect on barley***

- ***Improved nutrient availability by adding composted manure***
- ***Assessment of water quality in the Boyer River basin***

MII - Development of crop processor module for forage harvesters Under the Matching Investment Initiative, Dion Machinerie Inc. of Boisbriand, Que., cooperated with an SCRDC team to design and develop a roller mill crop processor module. It is the first module developed for pull-type forage harvesters in North America. They are currently marketing the module in Canada and the United States. This module makes it possible to synchronize cracking with chopping and blowing the chopped material. Cracking the stems of forage crops allows the material to be chopped more coarsely. This treatment promotes better mastication and digestibility in ruminants. For this achievement, the firm was selected as a finalist for the Partnership-Research Award presented by the department at Expo-Québec 1998.

Assessment of fungus on Timothy Fungi can affect the quality of forage conserved as hay or silage. It can also cause respiratory problems. Researchers measured concentrations of fungus spores on Timothy plants harvested at three stages of development. Spore concentrations

- were very high at the early stage
- fell dramatically at the more advanced stages
- varied but were not significantly different among the six cultivars studied.

Study of gas emissions from manure Animal manure is a significant source of carbon and nitrogen for agricultural soils. A portion of these elements is returned to the atmosphere in the form of greenhouse gases. In a study of soil amendment with solid dairy cattle manure, the manure

- produced the same amount of nitrous oxide per unit of nitrogen added to the soil as mineral fertilizers
- emitted about one-half of its carbon content as carbon dioxide during the year it was applied
- did not modify the oxidation of atmospheric methane by soil.

Monitoring the oxidation of soil organic matter Stable isotope C^{13} is naturally abundant in soil CO_2. This situation allows researchers to distinguish between CO_2

- ***New method to measure soil gas diffusivity***
- ***Improved nitrogen fixation***

- produced by respiration of plant roots
- generated by decomposition of soil organic matter.

The latter is closely correlated with soil temperature when water content is not a limiting factor.

Improved soil organic matter with manure application Manure application adds organic matter to soil and improves its structure. Studying the mechanisms of the biological and physical stabilization of soil organic matter contributes to the understanding and more effective management of this element. This study showed that formation and stabilization of soil aggregates following manure application

- are biological in origin
- allow physical protection of the organic matter within the aggregates.

Soil conservation with paper de-inking residues Recycling paper generates de-inking wastes that can be used to

- increase the organic matter content of agricultural soils
- improve their resistance to degradation.

As the residues decompose, they become coated with a layer of fine soil particles, forming aggregates that can withstand the dispersing action of water. The improvement in soil stability is still significant 3 years after the application of 50 or 100 Mg of residues per hectare. At these application rates, the residues are expected to remain for at least 8 years in the soil.

Reduced tillage in spring canola production In a study of different cultivation practices, researchers found that minimum tillage

- preserves soil structure and microbial life
- does not create adequate water infiltration conditions in the fall
- promotes more microbial activity.

In contrast, conventional tillage has more aggressive effects on soil structure, mechanically breaking up the aggregates and creating better conditions of water infiltration than minimum tillage. The effects of the chisel plough on soil properties often lie midway between those of minimum and conventional tillage.

Comparison of broad bean cultivars Broad bean (*Vicia faba* var. *major* L.) cultivars Métissa HO, its counterparts, Métissa ET and Métissa R96, and Optica HO from Holland are distinguished from other cultivars by their green seed yield. They have
- a determinate growth habit
- pod production localized on the plant
- more uniform pod maturation.

Cultivars FL3289.3, QF3049.5, and QF 3020.3 from Quebec and Médes from England have
- an indeterminate growth habit
- a long flowering period
- pods distributed on several inflorescences, so that the pods of the first inflorescences are ready for harvest before flowering is generally over
- less uniform, rather small seed.

Intensive forage conditioning A new pull-type prototype, designed to carry out intensive conditioning of forages independently of cutting, was manufactured in 1998. It was evaluated at several sites, including
- Nappan and Truro, N.S.
- the Lotbinière and Abitibi regions in Quebec.

This intensive conditioning technology
- reduces curing time in the field through accelerated drying
- can improve forage digestibility for ruminants.

New alfalfa cultivar AC Viva is a new alfalfa cultivar that
- produces 6% higher yields than Saranac
- is highly resistant to *Verticillium* and bacterial wilt.

New timothy cultivar AC Regal is a new timothy cultivar. This midseason cultivar produces very high yields, but its regrowth is inferior to that of the cultivar Champ.

Study of freezing tolerance of forage plants Researchers studied two alfalfa cultivars for the effects of cutting regime on
- crop density
- vigor of spring regrowth
- evolution and composition of carbon and nitrogen reserves.

Fall cutting had little effect on nonstructural carbohydrate reserves. However, marked differences were observed in the levels of certain basic amino acids and in storage protein accumulation for winter survival and spring regrowth.

Research was also conducted to evaluate genotypic variability for frost tolerance of
- orchard grass
- annual blue grass.

Changes in nonstructural carbohydrates were analyzed. Results indicated a link between
- high molecular weight fructosan accumulation
- cold adaptation in orchard grass.

A similar relationship was not observed in annual blue grass. This finding suggests different modes of adaptation between the species.

Micronization study Micronization is an infra-red heat treatment used commercially to increase the nondegradable protein content of soybeans. Whole soybeans were first soaked in a sugar solution to reduce the micronization temperature or residence time, or both, required to increase their nondegradable protein content. The increase was greater when the soybeans had first been soaked in a solution of lignosulfonate or molasses. However, micronization of soybeans soaked in a solution of lignosulfonate caused a reduction in in vitro digestibility of the dry matter.

The intensity of the observed reaction between proteins and sugars during a given heat treatment is a function of sugar type. The nondegradable protein content of soybeans can be optimized without affecting their digestibility by varying
- sugar type
- micronization temperature
- residence time after micronization.

Soil moisture estimates using remote sensing Currently, remote sensing sensors cannot be used to obtain soil moisture estimates for profiles deeper than about 10 cm. A system for obtaining soil moisture estimates for bare soils was developed and tested in two types of mineral soils. The system combines the use of

- an agrometeorological model (SWAP)
- the surface water content obtained by remote sensing.

This system could be used in the operational monitoring of the soil moisture balance.

Improved soil-moisture predictions Researchers have developed a nonlinear function of water extraction by roots for an agrometeorological model, SWAP. The addition of this function has significantly improved soil-moisture predictions obtained with this model.

Evaluation of weeds' effect on barley The effect of weeds on crop productivity varies depending on the production factor considered. Using an innovative statistical approach, researchers found that

- using an organic fertilizer had little effect on weeds but reduced biomass and yield in barley
- barley–forage rotations generated higher yields than barley monoculture, despite the greater presence of weeds
- reduced tillage intensity resulted in a decrease in barley biomass and yields, which is associated with increased weed populations.

Improved nutrient availability by adding composted manure Composted manure improves nutrient availability by releasing organic acids in the soil solution. During composting,

- the quantity of low molecular weight organic acids drops off over time
- volatile fatty acids accumulate at the start
- nonvolatile fatty acids dominate in advanced stages of maturation.

Assessment of water quality in the Boyer River basin The Boyer River is a spawning habitat for rainbow smelt, a commercial and recreational fish species. Water quality in this river has been impaired by high levels of nutrients and sediment. Researchers found that

- waters and sediments in the streams of the Boyer River basin were highly enriched with phosphorus
- drainage water had high nutrient concentrations
- farms with more phosphorus than is needed for spring grain and forage-crop rotations requirements are the most likely to contaminate surface waters
- on clay soils, a large share of the phosphorus migrates into drainage ditches in particulate form.

New method to measure soil gas diffusivity The centre has developed a new method to measure the speed of gas diffusion in a soil in the field, without disturbing its structure. This method

- makes it possible to integrate simultaneously all physical and environmental parameters of the soil that affect gas diffusivity
- provides a better understanding of the diffusion into the atmosphere of greenhouse gases and other gases critical to the biological processes of soils.

Improved nitrogen fixation Researchers have developed a new technology to create an effective combination for nitrogen fixation between an alfalfa cultivar and a strain of *Sinorhizobium meliloti.* This technology improves the establishment of inoculant strains in soils containing native populations of *Sinorhizobium*. Exchanges of chromosome genes, plasmids, and the high level of biodiversity of native populations of *S. meliloti* in Canadian soils affect

- the stability of commercial inoculant strains
- genetically modified microorganisms that are released into the environment.

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Mandate

The Dairy and Swine Research and Development Centre (DSRDC) in Lennoxville, Que., focuses on improving

- the productivity and profitability of dairy and swine production in Canada
- methods for beef and sheep production in eastern Canada.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $8.5 million through their operating budget, $2.6 million from the Matching Investment Initiative, $48 thousand from other special programs, and $21 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services. The centre manages

- a 350-ha farm and about 350 dairy cattle at Lennoxville
- a 370-ha farm and about 250 beef cattle at Kapuskasing.

Achievements

- ***Staff awards and honors***
- ***MII - Development of Porc Expert software***
- ***Better information on piglets' vitamin needs***
- ***Less heating and greater comfort for sows***
- ***New income-based model for pig feeding***
- ***New estrus synchronization program***
- ***Improved bovine embryo production***
- ***New method to determine sample size***
- ***Boost in good fat in lambs***
- ***Improved gains in lambs with protein supplements***
- ***Rejuvenation of old hay***
- ***Study of lactating cows fed fish oil***

Staff awards and honors Dr. Denis Petitclerc received the Canadian Association of Animal Breeder's award, for excellence in genetics and physiology.

MII - Development of Porc Expert software Porc Expert 2.0 is a software program developed under the Matching Investment Initiative in collaboration with the agri-food industry. It is used to predict the economic, zootechnical, and environmental impact of various

- feeding strategies
- management conditions.

It is an ideal tool for evaluating nitrogen and phosphorus wastes. Nutritionists from Canada, the United States, Mexico, Brazil, and Europe regularly use the software.

Better information on piglets' vitamin needs Early weaning substantially increases a sow's annual productivity. Its long-term success depends on the piglet's ability to adapt to this management technique. Vitamin requirements of the young animal are usually estimated on an empirical rather than a scientific basis. Metabolic measurements indicate that vitamin B_6 or pyridoxine is needed in much larger amounts than what is generally recommended in production.

Less heating and greater comfort for sows Maintaining a farrowing barn at 21°C in the winter is expensive and unnecessary. By controlling the temperature with heat lamps and giving piglets access to a niche, the ambient temperature may be gradually reduced to 15°C in the farrowing barn. As a result,

- piglets make better use of the heated area
- the sow's well-being is improved
- costs of production are reduced
- energy is saved.

New income-based model for pig feeding The centre recently developed a mathematical model that takes into account

- genetic characteristics
- management conditions
- available feeds.

This model makes it possible to determine the ideal feeding program for obtaining the best net income per feeding place per year. The results indicate that it is advantageous to reduce the quantity of protein fed, as long as carcasses maintain the same grading index.

New estrus synchronization program Researchers have developed a new estrus synchronization program that allows fixed-time insemination of beef cattle. In this program,

- gestation rates of nearly 95% were achieved during a 55-day breeding season
- gestation resulted from artificial insemination in more than 80% of the cases
- only 7–14 days of estrus observation were required, a 87–75% reduction
- there were savings of $30–$40 per insemination.

This program therefore saves both time and money.

Improved bovine embryo production Through ovarian physiology research, embryo production can be improved at any stage of the estrus cycle in cattle. A new program developed with Alliance Boviteq Inc. allows more-efficient management of the operations of the embryo transfer centre. Gestation rates of more than 55% are now obtained after the transfer of frozen embryos of determined sex. This project led to a licensing agreement between Agriculture and Agri-Food Canada and Alliance Boviteq Inc.

New method to determine sample size A new statistical method makes it possible to determine the sample size needed to identify the genotype of individuals of an animal population. This method

- helps geneticists determine the number of animals needed to detect an association between genetic markers and production traits
- eliminates the risks of having too small a sample (which could give misleading results) or too large a sample (which would needlessly increase costs)
- identifies the type of action of genes (additive or non-additive).

Boost in good fat in lambs Researchers carried out an experiment to evaluate extrusion as a means of reducing the degradability of canola protein. Unrelated to the goal of this study, they noticed that an extruded soybean or canola supplement boosted the polyunsaturated fatty acid content of lamb carcasses by about 20%. This discovery benefits the consumer, since the demand for foods containing this type of fatty acid is growing.

Improved gains in lambs with protein supplements Forages are often rich in rumen-degradable protein, which results in poor use of nitrogen by the animal. To overcome this situation, lambs receiving forages were given one of two protein supplements:

- fish meal
- canola meal.

Both supplements improved the average daily gain by about 34%. Heating the canola meal to reduce its rumen degradability provided no benefit, since this supplement produced gains similar to those obtained with fish meal at less cost.

Rejuvenation of old hay Ammoniation is used to increase the value of straw. Researchers studied the effect of ammonia-gas treatment of timothy hay harvested at an advanced stage of maturity. This post-harvest treatment improved the nutritive value of this forage by increasing

- fibre digestibility from 65 to 82%, a value comparable to that of the same hay harvested at the optimum growth stage
- crude protein content from 8 to 22%.

Thus, ammoniation is an excellent way of improving the nitrogen content and digestibility of lower-quality timothy hay.

Study of lactating cows fed fish oil Omega-3 fatty acids are required in appreciable amounts for optimum development of the nervous system in children. Researchers undertook to increase omega-3 fatty acid levels in milk by supplementing the cow's diet with fish oil, a major source of these fatty acids. The fish oil was fed to lactating cows in two forms:

- one protected from rumen degradation
- one unprotected.

The milk of cows fed fish oil had

- a sharp increase in the content of omega-3 fatty acids
- a lower protein and fat content.

The use of fish oil not protected from rumen degradation

- reduced the feed intake of lactating cows by more than 25%, hurting their performance
- made the milk more susceptible to oxidation and gave it an unpleasant taste.

Before this product is recommended for use, researchers need to

- develop excellent protection against rumen degradation
- establish the levels of supplementation.

Research Publications

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Mandate

The Horticulture Research and Development Centre (HRDC) in Saint-Jean-sur-Richelieu specializes in vegetable crops but also devotes some activities to meeting unique regional needs related to other crops. The centre meets research needs in the areas of production, protection, preservation of vegetable crops through

- precision farming
- biopesticide development
- advanced postharvest technologies.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $5.4 million through their operating budget, $3.9 million from the Matching Investment Initiative, and $150 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services. The centre is also responsible for operations on the following farms:

- Frelighsburg (134 ha)
- L'Acadie (86 ha)
- Sainte-Clotilde (32 ha).

Achievements

- *Staff awards and honors*
- *MII - Development of a root-crop yield monitor*
- *Updated genetic resource inventory*
- *Inventory of apple tree mortality*
- *English book on ornamentals*
- *Study of compatibility of Beauveria bassiana with pesticides*
- *Integrated control of crucifer pests*
- *Biological control of scab*
- *Study of pesticide resistance*
- *Use of Bt to control bertha armyworm*
- *Biological weed control*
- *Study of weed seed bank*
- *Quality monitoring using chlorophyl fluorescence*
- *Study of apple damage during storage*
- *Satellite monitoring of soil water content*
- *Improved growing conditions for transplants*
- *Introduction of AC Marie-Victorin*
- *Introduction of Lambert Closse*

Staff awards and honors Lucette Laflamme, a researcher in medicinal plant and crop management, received the Nicolas Appert Award from the *Fédération québécoise des producteurs de fruits et de légumes de transformation.* The award was for her work with producers, particularly on a cultivar-testing network for

- pea
- bean
- sweet corn.

Nicolas Tremblay, a researcher in plant nutrition, was awarded the Agcellence Award for his leadership in the Quebec vegetable sector. Mr. Tremblay researches both fresh and processing vegetables, medicinal plants, and remote sensing. His work on the introduction of new, environmentally friendly crops and cultural practices has a significant impact on producers and the horticultural industry.
Mr. Tremblay also promotes the diversity and value of the skills of his colleagues at the centre among sector stakeholders.

MII - Development of a root-crop yield monitor Under the Matching Investment Initiative, Innotag Inc. and the centre designed and manufactured an electronic interface. This system integrates weight measurement and vegetable harvester conveyor speed sensors with RDS data-logging instruments. Innotag has bought the rights to the electronic interface and is selling the systems in Canada and the United States. RDS Technology Ltd., which distributes at the international level, is marketing the system under the name CERES 2 RCYM.

Updated genetic resource inventory Pedigree is a inventory system of genetic resources that contains basic data (parents, origin, characteristics, diseases) for many fruit crops, including

- apples
- strawberries
- almonds

- blackberries
- blueberries
- pears.

The software, developed for plant breeders and researchers, was updated and adapted to the Windows 95 environment by Shiv O. Prasher (Regd.) Ltd., marketer of the software since 1997.

Inventory of apple tree mortality From April 1994 to March 1996, the *Fédération des producteurs de pommes du Québec* co-funded a study to inventory apple-tree mortality following temperature fluctuations during the winter of 1993. The study will be used by the apple industry to select for aspects best suited to the weather conditions in apple-growing regions of the province, such as

- cultural practices
- site
- tree health
- rootstock and cultivars.

English book on ornamentals Ms. Claude Richer has published the findings of the *Réseau d'essais des plantes ligneuses ornementales du Québec* (REPLOQ) in English. The book was published in cooperation with the *Conseil des productions végétales du Québec* under the title *Hardiness and Growth of Woody Ornamental Plants in Quebec.*

Study of compatibility of Beauveria bassiana with pesticides *Beauveria bassiana* is a fungus used to control Colorado potato beetle adults. Researchers evaluated the effect on this fungus of six fungicides and two herbicides used in potato production. All the fungicides and one of the herbicides evaluated inhibited mycelium growth in *Beauveria.* The other herbicide, diquat, increased the insecticidal activity of *B. bassiana* and caused 50–76% mortality.

Integrated control of crucifer pests Diamondback moth and imported cabbageworm are two important pests of crucifers. Egg parasitoids are used in biocontrol of these pests. They are most effective when their release coincides with egg-laying by the pest insects. To better synchronize the release of egg parasitoids, researchers evaluated the reliability of degree-day (DD) accumulation for predicting first emergence of the pests.

The average length of a generation was

- 352.7 DD above 7.3°C for diamondback moth
- 319.7 DD above 10°C for imported cabbageworm.

Unfortunately the considerable overlap between generations of diamondback moth substantially reduces the usefulness of predictions based on DD accumulations for this species.

Biological control of scab The fungus *Microsphaeropsis* sp. has a clear antagonistic effect on apple scab when applied on the leaf litter in the fall. Its use as part of an integrated control program would be valuable in reducing inoculum of *Venturia inaequalis*, the scab fungus that overwinters in leaves at the base of apple trees. Reductions of inoculum would in turn reduce spring infections.

Study of pesticide resistance In cooperation with the Pacific Agri-Food Research Centre in Summerland, B.C., researchers studied the larvae of a strain of obliquebanded leafrollers, *Choristoneura rosaceana*, that had developed resistance to azinphosmethyl. They found that this resistance was lost in three to four generations in the absence of organophosphorus pesticides. The instability of resistance, associated with esterase enzyme activity, will allow apple growers and advisors from the Deux-Montagnes region of Quebec to manage the problem of resistance in the medium term.

Use of Bt to control bertha armyworm Bertha armyworm, *Mamestra configurata* Wlk., is an economically important pest of canola. A total of 102 strains of *Bacillus thuringiensis* Berliner were

- isolated from six types of soil and dust from grain storage bins in Canada
- evaluated to determine their toxicity to bertha armyworm.

Soil isolate A1.2/72, subsp. *kurstaki*, was 15 times more toxic to bertha armyworm larvae than the international standard (HD1-S-1980). More extensive research is under way to develop this isolate for the biological control of bertha armyworm.

Biological weed control In a research project funded by Canadian International Development Agency in Burkina Faso, researchers described the vertical distribution of the larvae of two weevils:

- *Smicronyx guineanus* Voss.

- *S. umbrinus* Hustache.

Results showed that the weevil larvae occur in the upper part of *Striga hermonthica* (Del.) Benth. They cause galls and destroy large quantities of seed. Thus, the weevils could be used for the biological control of *Striga*, an important weed that parastizes food crops, such as

- sorghum
- millet
- maize.

Study of weed seed bank In a study of the abundance of *Chenopodium* seeds in the soil of tilled fields in Oxford County, Ont., researchers found that

- cropping sequence had no effect on seed abundance
- manure application considerably increased the weed seed bank in the same crops.

Of the 100 seeds collected,

- 10 were viable
- 56 were damaged
- 34 had not entirely completed their development.

Quality monitoring using chlorophyll fluorescence Researchers measured chlorophyll fluorescence on the flower and stem of broccoli at two stages of maturity in order to determine postharvest quality. The stage of maturity of broccoli did not affect fluorescence measurements, as long as measurements were taken on the flowers and stem. This technique can therefore be adopted to evaluate the postharvest quality of stored broccoli.

This technique was also evaluated on McIntosh apples in controlled atmosphere storage. Results showed that it can rapidly detect stress in stored apples caused by

- shortage of O_2
- excess of CO_2

This technique will help avoid appreciable losses during storage.

Study of apple damage during storage The effect of low temperatures (0 or 3°C) was measured on Nova Scotia-grown Cortland apples kept in

- standard controlled atmosphere (CA) storage
- low-oxygen CA storage.

After 4 and 8 months, the apples held at 0°C showed signs of several physiological problems caused by low temperatures, but these were unrelated to oxygen levels in the storage facilities.

Satellite monitoring of soil water content The RADARSAT satellite, with its temporal periodicity, is a valuable tool for monitoring crops and soil water content. In organic soils, researchers established a relationship between soil water content and the hyperfrequencies measured with a scatterometer operating according to the satellite configuration. However, corrections must be made as a function of

- cultural practices or the rugosity of the tilled or rolled surface
- the direction of furrows
- vegetation cover.

The optimal configuration for monitoring the water content of harrowed and rolled plots was done before vegetation became established at incidence angles of

- 25° (HH)
- 30° (VV).

Improved growing conditions for transplants Young plants grow very quickly and benefit more from optimal growth conditions than mature plants. Vegetable transplant growers can take advantage of these growth factors to shorten the production period and offer better-quality transplants. Enrichment of carbon dioxide and a light supplement in greenhouses enhances the photosynthesis of the plantlets, resulting in better quality transplants in a shorter time.

Introduction of AC Marie-Victorin The centre has developed a new rose in the Explorer series, AC Marie-Victorin. The flowers of this small, hardy shrub rose

- bloom from June to late September
- are borne in clusters of one to six blooms
- fade from peach to pale pink at maturity
- are suitable as buds for boutonnieres.

Named after internationally renowned botanist Father Marie-Victorin, founder of the Montreal Botanical Garden, AC Marie-Victorin is resistant to mildew and blackspot. The HRDC has granted propagation and marketing licences to eight Canadian nurseries:

- five in Quebec
- one in New Brunswick
- one in Ontario
- one in British Columbia.

Introduction of Lambert Closse HRDC has introduced a winter-hardy shrub rose, Lambert Closse. One of the Explorer series, it was named after an early 17th-century explorer in Canada. This rose

- has pink flowers
- blooms from June to September
- is resistant to mildew and blackspot to zone 5.

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RESEARCH BRANCH DIRECTORY OF RESEARCH 1998 - 1999

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Food technologies, microbiology P. Fustier, M.Sc.
Starchy products, fermentation P. Gélinas, Ph.D.
Electrotechnologies and proteins F. Lamarche, Ph.D.

Mandate

The Food Research and Development Centre in Saint-Hyacinthe (FRDC) helps Canada's food industry become more competitive by conducting research in the area of food processing. The centre also promotes the development and transfer of new technologies by

- providing Canada's food and beverage industry with a technological environment to conduct R & D work
- making scientific and technical staff available to the industry for the implementation of its research and development projects.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $8 million through their operating budget, $4.6 million from the Matching Investment Initiative, and $18 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

The centre uses a wide range of specialized, modern instruments to carry out advanced research in food science. It also has pilot plants with equipment specially designed to develop new products. The centre shares its premises with employees of the Maple Products Research Centre ACER inc. (a nonprofit organization) and a technology adviser of the National Research Council of Canada.

Achievements

- ***Staff awards and honors***
- ***MII - Lactic fermentation of vegetables***
- ***Industry services***
- ***Library and information services***
- ***Events***
- ***Publications***
- ***Negotiation of institutional agreement***
- ***Project development for new institute***
- ***Special projects***
- ***International programs***
- ***Antimicrobial films for packaging meat products***
- ***New pilot plant***
- ***New food-processing machine***
- ***New method to evaluate ham quality***
- ***Assessment of bacterial incidence***
- ***Effects of modified atmospheres on shelf life***
- ***Study of yeast extracts***
- ***Fermentation of milk with immobilized cells***
- ***New food colorant from red cabbage***
- ***New process to produce proanthocyanidins***
- ***Study of flavor release and perception***

- *Bioproduction of flavors*
- *Human feeding trial with kefir*
- *Recombinant enzyme tests*
- *Production of bioactive peptides*
- *Production of nutraceuticals from whey*
- *Genetic identification of lactic acid bacteria*
- *New pilot oven for pastry products*
- *Production of potato products*
- *New process to dry cranberries*
- *New ultrasound method to determine residence time distribution*
- *Testing for flour functionality*
- *Longer shelf life with vitamin E packaging*
- *Packaging for ready-to-eat food products*
- *Caseinate films*

Staff awards and honors Claude Aubé, former director of the Food Research and Development Centre and director general of the Governors' Foundation since September 1998, received an honorary doctorate from the University of Montreal in June 1998. This honor recognizes Dr. Aubé's contribution to the position of influence gained by the Saint-Hyacinthe region in the agri-food sector, both nationally and internationally. The ceremony was part of Saint-Hyacinthe's 250th anniversary celebrations and it's 50th anniversary of University of Montreal's Faculty of Veterinary Medicine. Gilles Doyon, Alain Clément, Louisette Trahan, and Pierre Brouillette received an Agriculture and Agri-Food Canada Agcellence Award for their contribution to the agri-food sector through their work on optimizing transoceanic transportation conditions for fresh fruits and vegetables.

Claude Champagne and Nancy Gardner received an Agcellence Award for innovation, for developing a fast, effective method to evaluate the biological value of food ingredients.

Lallemand Inc. and centre researcher Claude Champagne received an Agriculture and Agri-Food Canada Partership Award. Special mention was made of A. Lassonde & Fils and centre researchers Michèle Marcotte and François Lamarche.

Steve Bittner received an Agriculture and Agri-Food Canada Research Branch Award for industry services.

The Federal Regional Council, Quebec program, recognized centre staff Claude Aubé, Christian Toupin, Jean Gagnon, Steve Bittner, and Élisabeth Gauthier. Also mentioned were Ronald Cyr of DEC-Québec, Raymond S. Roy and Youssef ElAzhary of the Faculty of Veterinary Medicine, University of Montreal, David Hurley of South Dakota State University, and Serge Hébert of Bioagral Inc. The award was for excellence in their contribution to creating the Veterinary and Food Biotechnology Institute. This project will enhance the diffusion of federal public services expertise.

- *Electrodialysis of apple juice*
- *Electroflotation to clarify apple juice*
- *Provision of international training*
- *New technique to identify blueberries*
- *Development of antimicrobial films*
- *Prevention of haze in clarified apple juice*
- *Characterization of polysaccharide production*
- *Assessment of bifidobacteria in cheese making*
- *Cheese production with strains of lactococcus*
- *New method to measure residual rennet in cheese*
- *Cheese dehydration kinetics upon cooking*
- *Reduction of syneresis in yogurts*
- *Cascade microfiltration of whole milk*
- *Production of protein-based packaging films*

Caldwell Bio Fermentation Canada Inc. (Bio-Lacto) and Claude Champagne, Nancy Gardner, and Louise Deschênes of the centre received the Governors' Foundation Innovation Award for work on the production of fermented vegetables.

MII - Lactic fermentation of vegetables The award-winning project with Caldwell Bio Fermentation Canada Inc. involves fermenting vegetables with lactic acid bacteria and preserving them without pasteurization or preservatives. The resulting food products are unique in the world.

Researchers found that the final pH and organic acid content of the fermented product was influenced by
- the lactobacillus, pediococcus, or *Leuconostoc* composition of the starters
- the rate of acidification.

This study helped to improve the preservation of fermented vegetables that are marketed without being pasteurized. A viability study of lactic culture determined the best-before dates of fermented vegetables based on their biological and potential probiotic content.

Industry services One of the major attractions of the centre is that it allows industries themselves to carry out research in pilot plants. In 1997–1998, 78 confidential industrial projects involving 70 companies (including 47 new ones) were carried out. Under a cost-recovery program, these projects brought in revenues of $300 000.

The industrial program
- allows industries to benefit from rapid technology transfer into production
- maintains a high level of confidentiality
- has ISO 9002 accreditation
- operates under the policy, "Simple, quick access to a versatile food R & D environment."

Library and information services The centre's library and information retrieval and analysis service, offered in partnership with the Governors' Foundation, answered more than 600 requests from industrial clients. Clients are able to quickly obtain the information they want in the appropriate format through
- bibliographic research
- documentary summaries
- retrieval and copying of documents.

Events The centre was involved in
- the inauguration of the Food Industry Pavilion, in September 1997. Seven knowledge-transfer activities targeted at various sectors in the food industry were held, attracting more than 300 participants
- cooperating with Governors' Foundation personnel to organize BioAgro Contact 98, the annual agri-food biotechnology rendezvous. It was held in Saint-Hyacinthe on 9–10 November and attracted about 300 participants
- welcoming more than 1500 visitors of all ages to its own open house in May 1998
- coordinating the participation of Research Branch centres in Quebec in the Saint-Hyacinthe Agri-Food Festival, an event commemorating the city's 250th anniversary.

Publications Three books were written by centre researchers and published jointly by the Governors' Foundation and other scientific publishing houses.

Negotiation of institutional agreement An institutional agreement was negotiated between the centre and the *Haute école Lucia de Brouckère* of the Meurice Institute in Brussels, Belgium.

Project development for new institute Centre staff are actively involved in the creation of the Veterinary and Food Biotechnology Institute (IBVA), affiliated with the Faculty of Veterinary Medicine of the University of Montreal. The IBVA's main research focus is the discovery of encapsulation matrices and molecular targeting and their application to meet the needs of the agri-food and veterinary sectors. The project
- will allow collaboration between the institute, the centre, and a major network of public and private organizations in Canada, the United States, and Europe
- involves developing fully integrated electron microscopy and analytical spectroscopy centre at the FRDC.

Special projects A specialized firm was commissioned to carry out a study on the centre's 5-year strategic planning for 1998–2003.

The centre continued to evaluate the proposed creation of a technological innovation and incubation centre for R & D enterprises involved in food biotechnology.

International programs In 1998–1999, the centre followed up on the "Quality Forum in Francophone Countries" and on initiatives to assist development in Haiti. In the future, the centre intends to emphasize activities involving exchanges and support for information access, primarily in the francophone world.

Antimicrobial films for packaging meat products Researchers developed a process to produce an antimicrobial film for deli-food packaging. This process involved
- including organic acids in a fine matrix of chitosan
- measuring the gradual salting-out of acids in the aqueous phase
- slowing the salting-out by including hydrophobic compounds extracted from essential oils of cinnamon and clove in the matrix.

The resulting films were then evaluated for their ability to retard the growth of food-spoiling bacteria on the surface of vacuum-packaged deli products during storage at refrigeration temperatures.

Generally, the controlled salting-out of organic acids
- did not slow the growth of lactic bacteria
- slowed the growth of enterobacteria significantly.

These findings suggest a protective effect against the development of certain pathogenic bacteria, even if the products do not have a longer shelf life.

New pilot plant A new pilot plant to produce meat products was established on the premises of the University of Montreal's Faculty of Veterinary Medicine at Saint-Hyacinthe. This new plant
- allows safe handling of the most common pathogenic bacteria
- will be used to conduct joint projects between the centre and university faculty.

These projects will
- evaluate the effectiveness of routine industrial processes in destroying pathogenic bacteria during meat processing
- gather the basic knowledge required to develop safer processes.

New food-processing machine The centre has acquired a pilot high-pressure food-processing machine. It will be used
- to carry out research projects to improve the functional properties of animal and plant proteins
- to perform cold pasteurization of fruit juices, vegetable purees, and meat products.

New method to evaluate ham quality Researchers have developed a simple and precise method to evaluate the technological quality of legs of pork. This method
- will be used by the *Centre de développement du porc du Québec* as part of its quality evaluation program
- takes into account not only the complexity of the various leg muscles, but also the North American ham-processing context
- allows the monitoring of genetic advances affecting the production of meat cuts for further processing
- provides a quality-control tool for processors.

Assessment of bacterial incidence *Brochothrix thermosphacta* is an organism that spoils sliced and vacuum-packaged meat products. It is able to develop when the pH is near neutral and residual oxygen is present. Its presence is characterized by dairy odors.

Researchers undertook a study of three meat processors in Quebec to determine the incidence of this microorganism in their products at the end of their shelf life. Results indicate that
- the incidence is sporadic for some processors but more significant for others
- certain environmental and hygiene factors may be responsible for the differences observed.

Effects of modified atmospheres on shelf life Boning chicken by belt-separation technology gives a product that can be sold directly as fresh ground meat. Researchers cooperated with an industrial collaborator to study shelf life of ground chicken or turkey under two atmospheric conditions:
- gas 1: with no oxygen (20% CO_2 and 80% N_2)
- gas 2: containing 8% oxygen (62% CO_2 and 30% N_2).

The ground poultry meat packaged under gas 1
- maintained a more attractive color than that packaged under gas 2
- had microbial counts for coliforms and *Escherichia coli* over the acceptable limit established by the Canadian Food Inspection Agency after 12 days of storage at 1°C.

None of the chicken and turkey samples packaged under gas 2 had microbiological counts over the acceptable limits after 15 days of storage.

These results indicate that
- an appropriate mix of gases can give a meat of acceptable color
- this color provides no guarantee that the product is of acceptable microbiological quality.

Study of yeast extracts Proteases improve the physical properties of yeast extracts and some also improve their biological properties. Researchers collaborated with a company to study the effect of adding enzymes during the preparation of yeast extracts.

They studied the following properties of the extracts obtained:

- chemical
- physical
- biological.

The results will be used to improve the product for market.

Fermentation of milk with immobilized cells Researchers collaborated with a company to develop a method to ferment milk by preparing the starter with lyophilized immobilized cells. This method

- produces acidification curves similar to those obtained after inoculation with traditional liquid starters
- is based on a stage of rehydration of the immobilized cells under special conditions.

New food colorant from red cabbage Researchers developed a process to deodorize cabbage extracts at the laboratory scale. The colorant obtained

- has greater temperature stability over a wider pH range than colorants obtained from small fruits
- does not contain any oxidized phenols that produce an undesirable brown color over time, unlike colorants from small fruits.

New process to produce proanthocyanidins As part of a collaboration agreement with an industrial partner, researchers developed a laboratory-scale process to produce proanthocyanidins of high purity.

Study of flavor release and perception Researchers analyzed samples from a mastication experiment using an image-analyzing technique. This method

- allowed them to characterize the particle-size distribution of almond pieces after whole almonds were chewed
- is designed to evaluate the chewing efficiency of individuals.

Bioproduction of flavors Researchers characterized lipoxygenase enzyme from *Morchella esculenta* to produce four isomers of hydroperoxides. Degenerated primers were designed on conserved regions of known lipoxygene genes. Using these primers, cDNA was amplified from *M. esculenta* and dark grown seedlings of soybean by polymerase chain reaction. Researchers characterized six clones from soybean and used them as probes to determine positive clones of *M. esculenta.*

Human feeding trial with kefir In cooperation with McGill University, researchers ran a feeding trial to determine the effect of kefir on the cholesterol level of humans who have elevated plasma cholesterol. Blood and fecal samples were taken to measure changes in the subjects'

- cholesterol metabolism
- intestinal microflora.

Initial results seem to indicate several beneficial effects on health, but not necessarily on the cholesterol level.

Recombinant enzyme tests The centre sent a recombinant aminopeptidase to three industries in Canada and the United States

- to carry out cheese-ripening tests
- to reduce the bitterness of protein hydrolysates.

The recombinant aminopeptidase proved effective in eliminating the bitterness. Preliminary results seem to indicate its effectiveness in cheese ripening.

Recombinant lactates of the bacteria *Streptococcus thermophilus* and *Bifidobacterium infantis* are overproduced in *E. coli.* These lactases are used to convert whey into galacto-oligosaccharides, a major probiotic. Conversion rates of about 55% were achieved.

Production of bioactive peptides Researchers are preparing several bioactive peptides, especially antihypertensive peptides, using commercial and lactobacillus enzymes. Some peptides produced by the use of lactobacillus enzymes contain the sites of two antihypertensive peptides of ß-casein.

Production of nutraceuticals from whey Researchers developed a process to ferment whey using the yeast *Kluyveromyces marxianus*

- to reduce the polluting potential of whey
- to produce high value-added nutraceuticals, such as oligonucleotides, oligosaccharides, and oligopeptides.

Yeast metabolized 95% of the lactose during the fed-batch mode fermentation. The following were obtained:

- production of dry biomass (28–30 g/L)
- concentrations of 5'-ribonucleotides (3 mg/g)
- four-unit oligosaccharides
- hydrophilic and hydrophobic oligopeptides.

The presence of a site containing the ß-lactophine sequence (YLLF) suggests antihypertensive properties.

Genetic identification of lactic acid bacteria The development of new methods to genetically identify microorganisms made it possible for researchers to identify a commercial starter and establish its specific genetic profile. The identification work was carried out as part of two industrial collaborations.

The identification methods are based on a principle of restricted fragment length polymorphism and a probe obtained by polymerase chain reaction. In one case, identical strains could be differentiated in one group of lactic acid bacteria of the same subspecies. This ability allowed the industry to determine the components and potential of its starters.

New pilot oven for pastry products An experimental pilot oven for baking pastries and biscuits was built and installed at the centre. The Electrochemistry and Electrotechnologies Laboratory of Hydro-Quebec and a private firm cooperated in this undertaking. Software for oven control and data acquisition is now being designed. Researchers also evaluated the energy costs of various baking profiles under the Program of Energy Research and Development of the Department of Natural Resources.

Production of potato products The centre cooperated with the *Centre de recherche en économie agro-alimentaire* to complete the technical–economic study of establishing a production line for potato flour, granules, and starch. This study was funded jointly by the Conseil des recherches en pêche et en agroalimentaire du Québec and the *Fédération des producteurs de pommes de terre du Québec.*

The study found that
- the potato starch production process was technically complex and might not be economically viable in Quebec
- the flour or granules production line was more technically feasible and cost-effective in Quebec.

New process to dry cranberries Researchers worked with a private firm to develop a process to dehydrate. It
- allows to obtain an acceptable organoleptic quality
- permits prolonged storage of dried cranberries.

The firm may soon make commercial use of these findings. This project also involved comparing energy costs under the Program of Energy Research and Development, Department of Natural Resources.

New ultrasound method to determine residence time distribution Researchers developed and validated a new ultrasound method with the Industrial Materials Institute of the National Research Council of Canada. This method determines the distribution of residence times in a continuous ohmic heating column used to heat sauces containing carrot particles. The method
- offers several advantages over existing methods, including the possibility of conducting high-temperature experiments on two-phase systems containing several particles
- compares favorably with the magnets commonly used in the industry to validate aseptic processes, since it eliminates the metal inference problems caused by the presence of metal electrodes during ohmic heating.

Testing for flour functionality Quality control during biscuit manufacturing requires establishing characterization parameters at all stages of the process. Researchers validated the following characteristics on flour–water doughs:
- physicochemical characteristics of the flour
- rheological behavior of the dough during and after kneading
- biscuit-making properties.

Biscuit tests were statistically validated on 36 commercial soft wheat flours to evaluate flours based on their functionality for biscuit baking. Correlations were established between these various parameters as tools to measure the processing quality of flour.

Longer shelf life with vitamin E packaging Researchers collaborated with an industrial partner to show the advantage of using packaging containing vitamin E to increase the shelf life of lacto-fermented products.

Packaging for ready-to-eat products Most trays and membrane closures used to package ready-to-serve foods are made of plastic. Researchers investigated the potential of polyethylene terephtalate (PET) for manufacturing a complete, effective, and safe system of packaging. They showed the non-uniform character of PET Selar used as a membrane closure and sealant.

Caseinate films A permeability study carried out on plastic films made from dairy proteins showed the usefulness of glycerol as a plastifying agent. Glycerol reduces the rate of oxygen transmission in the film. By irradiating the solutions, films are made more resistant to moisture.

Electrodialysis of apple juice The centre, with Laval University, is carrying out electrodialysis in opalescent fresh apple juice to inhibit enzymatic browning. Various electrodialysis cell configurations were designed and tried. Through electrodialysis using bipolar membranes, the pH of an apple juice is reduced to 2 without chemical additives. After electrotreatment, the pH is adjusted to the initial value. Organoleptic analysis showed that juice treated by electrodialysis has
- the color of a freshly pressed juice
- a pleasant fruity taste.

Electroflotation to clarify apple juice
Electroflotation has been used to clarify slaughterhouse sludge by reducing the quantity of organic wastes. The method involves
- adding a fining agent (gelatin or bentonite earth)
- separating the floc from the liquid in an electroflotation cell.

Researchers adapted this method to the clarification of apple juice. The project is being carried out with an industrial partner and Laval University.

Provision of international training The centre gave a course on postharvest storage of crops at Yamoussoukro, Ivory Coast. The course covered
- the use of laboratories postharvest crop preservation using modified atmospheres
- transportation
- the operation of modified atmosphere rooms.

The course benefited industrial entrepreneurs and members of various research centres in the country.

New technique to identify blueberries Researchers developed this technique to identify blueberries picked in Quebec. This technique is based on organic acids profile. It can distinguish between the *Verticillium* varieties
- *V. myrtilloïdes*
- *V. corymbosum*
- *V. angustifolium.*

Development of antimicrobial films Researchers developed various types of antimicrobial films to use in packaging foods. The studies focused on the mechanical properties of the films in relation to various production parameters.

Prevention of haze in clarified apple juice Under a collaborative agreement with an industrial partner, researchers
- analyzed the composition of the haze sediments that form in clarified apple juice during storage
- identified factors influencing the development of these hazes
- proposed techniques to slow down or prevent haze formation.

Results from this study will provide the industry with information to help them improve their
- process
- product quality.

Characterization of polysaccharide production As part of the lactic acid bacteria research network, researchers typed casei group lactobacillus strains that produce exopolysaccharides (EPS). They used genetic methods such as randomly amplified polymorphic DNA.

The following strains were selected because they can produce EPS at rates of more than 50 mg/L:
- *Lactobacilles rhamnosus* ATCC 9595M (up to 1200 mg/L)
- *L. rhamnosus* R (600 mg/L).
- *L. paracasei* V.

As a result of this study, the *L. rhamnosus* (9595M) strain can be classed among the best EPS-producing strains of lactic acid bacteria known to date.

Assessment of bifidobacteria in cheese making
Adding bifidobacteria during cheese making influences the fermentation kinetics of lactic acid bacteria in terms of
- pH reduction
- appearance of titratable acidity
- use of sugars
- flavor development.

However, it does not affect the growth of lactic acid bacteria.

As part of the lactic acid bacteria research network, researchers produced fresh cheese by using combinations of acid-forming lactococci and flavoring leuconostocs in various proportions. The mixture was enriched with protein by adding native phosphocaseinate obtained by microfiltration. The bifidobacteria added to the fresh cheese were

- *Bifidobacterium bifidumi*
- *B. breve*
- *B. longum*
- *B. infantis.*

The growth and metabolic activity of various species of bifidobacteria are affected by

- incubation temperature
- protein enrichment
- ratio of acid-producing bacteria to flavor-producing bacteria.

Cheese production with strains of lactococcus Researchers used two strains of lactococcus to produce cheddar cheese:

- one with X-prolyl dipeptidyl aminopeptidase (PepX+)
- one without this peptidase (PepX–).

The study concluded that

- cheeses obtained with the PepX– strain were firmer and slightly less fruity and bitter than the cheeses produced with the PepX+ strain
- bitterness could not be explained solely by the presence or absence of PepX–.

PepX– is not recommended for use in cheese production, because it requires 2 h more time compared with the PepX+ strain. This project was carried out with the National Agricultural Research Institute, Jouy-en-Josas, France.

New method to measure residual rennet in cheese In cheese production, rennet is added to the milk to make it curdle. A large portion of this enzyme is eliminated with the whey when it is drained off. However, the amount of rennet remaining in the curd has a significant impact on cheese ripening, because it initiates casein hydrolysis. Researchers developed a spectrophotometric method to estimate the quantity of residual rennet in cheddar and mozzarella cheeses.

Cheese dehydration kinetics upon cooking Mozzarella cheese is mainly used as a pizza topping because of its melting properties. Dehydration of mozzarella cheese during cooking influences its behavior. Too-rapid dehydration results in incomplete melting and excessive browning. The dehydration kinetics of cheese during cooking therefore has a significant impact on product quality.

Researchers developed an objective method to measure water lost from cheese during cooking. Application of an empirical model to the experimental data makes it possible to express the rate of evaporation by unit of area, based on cooking time. These data are useful in quantifying the effectiveness of treatments in delaying dehydration.

Reduction of syneresis in yogurts The separation of a clear liquid on the surface of yogurts, called syneresis, is a major defect. Researchers developed an ingredient made of whey proteins to minimize this problem. The process involves

- applying heat to a serum protein solution in a controlled mineral environment
- optimizing the heating conditions to increase the water retention of the proteins while limiting aggregation.

The partial substitution of milk proteins by this ingredient increases firmness and significantly reduces syneresis.

Cascade microfiltration of whole milk Researchers developed a new process to fractionate milk fat based on the size of fat globules. Fraction analysis revealed a difference in the triglyceride and fatty acid composition of the fractions. Light cheeses (17% milk fat) were produced from a cream rich in large globules.

Analysis of the cheeses shows that use of this fraction results in improved

- texture
- flavor
- appearance.

Steps are being taken to protect this technology.

Production of protein-based packaging films Researchers used concentrates of proteins from dairy products to make biodegradable packaging films. This work was done in collaboration with the *Institut Armand-Frappier*.

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Mandate

The Eastern Cereal and Oilseed Research Centre (ECORC) serves and supports Canadian agriculture by developing

- improved varieties of barley, corn, oats, soybeans, and wheat, with value-added traits
- integrated agronomic systems.

The centre provides systematic expertise on plants, fungi, insects, and acari for

- biocontrol research
- border protection
- crop genetic improvement
- crop protection.

The mandate also includes

- providing biotechnological tools to support crop improvement and protection, and systematics
- assessing land resource and production systems
- providing data integration on maps to support land resource management and policy.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $28.7 million through their operating budget, $4.9 million from the Matching Investment Initiative, $269 thousand from other special programs, and $183 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

ECORC is located in Ottawa on the 500-ha Central Experimental Farm. At this site the centre maintains

- experimental fields and plots
- greenhouse and growth facilities
- the arboretum
- ornamental gardens.

ECORC maintains and enhances the following reference collections and databases:

- the Canadian Collection of Fungal Cultures
- the Canadian National Collection of Insects, Arachnids and Nematodes
- the National Mycology Herbarium
- the Vascular Plant Herbarium
- the National Soil Database.

ECORC is renewing and consolidating programs and facilities on the Central Experimental Farm, primarily in the K.W. Neatby Building, with further work proposed for future years.

Achievements

- *Staff awards and honors*
- *MII - Fusarium consortium*
- *New barley varieties*
- *Barley DNA fingerprinting*
- *New corn lines*
- *Tests for corn quality*
- *Evaluation for resistance to Fusarium and other pests in corn*
- *Transformation for Fusarium resistance*
- *Molecular tools to control Fusarium resistance in corn*
- *Prediction of plant development*
- *Nitrogen fertilization*
- *Mapping of the oat genome*
- *Oat quality analysis*
- *New soybean varieties*
- *Indicator of soybean quality*
- *Transformation for disease resistance in soybeans*
- *Soybean gene expression*
- *New winter wheat varieties*
- *Fusarium resistance in wheat*
- *Wheat quality analysis*
- *New developments in oilseed biotechnology*
- *Dissection of constitutive promoter*
- *Control of fungal growth*
- *New method to predict fate of microorganisms*
- *Molecular diagnosis of disappearing root rot of ginseng*
- *Bulletin describing flax fungus*
- *Trichoderma identification*
- *Crucifera trait genetics*
- *Cruciferae genetic resources*
- *Brome seed identification*
- *Biological control of bertha armyworm*
- *Cutworm moth identification*
- *Identification of Canadian casebearer species*
- *Identification of the genus Monotoma*
- *Identification of the Lepidoptera families in Quebec*
- *Aid for identifying histerid beetles*
- *Assessment of species diversity in the Montane Cordillera Ecozone*
- *Implementation of taxonomic information systems*
- *Use of national reference collections*
- *New climate database*
- *Agricultural use of climate information*
- *Revised edition of the Canadian System of Soil Classification*
- *Electronic availability of land and soil maps*
- *Composting sewage sludge*

Staff awards and honors Dr. N. McLaughlin received the Glenn Downing Award from the Canadian Society of Agricultural Engineering for outstanding achievements in research, extension, and teaching in power and machinery.

Dr. A. McElroy was awarded a Fellowship of the Canadian Society of Agronomy in recognition of research in forage genetics and, in particular, pioneering work in breeding for improved forage feeding value and applying near infrared reflectance spectroscopy to assess forage quality.

Mr. P. Schut received an Award of Merit from the Earth Science Sector, Natural Resources Canada, for his role in developing the Canadian Geospatial Data Infrastructure.

The team of Ms. B. Brookes, Mr. M. Jomphe, Mr. D. Munro, and Dr. E. Small received Agriculture and Agri-Food Canada Agcellence awards for collaboration in producing the books, *Culinary herbs* and *Vegetables of Canada.*

Dr. J. McKenzie received an Agriculture and Agri-Food Canada Agcellence Award for his contributions to the department's ethanol management committee.

MII - Fusarium consortium The Ontario Corn Producers' Association has identified *Fusarium graminearum* ear mold as a serious threat to the Ontario corn crop. A research and development consortium involving the public and private sectors has been established to address this concern. The centre is carrying out a 4-year research project to develop *Fusarium*-resistant corn varieties using various biotechnology tools, including molecular markers, to select highly productive cultivars for Ontario's climate. This research is supported by the R&D consortium and funded under the Matching Investment Initiative at a projected $800 thousand. As new lines are developed, the consortium's company partners will play a greater role in transferring the technologies to their particular hybrids and the seed corn marketplace.

New barley varieties Six feed barley varieties were registered in 1998:

- AC Westech, a six-row barley with high yield and good threshability in the Maritimes
- AC Legend, a six-row feed barley similar in maturity and plant height to the long-established check, Chapais, but yielding 4–8% more in eastern Canada
- AC Kings and AC Queens, two-row barleys well adapted to Ontario and the Maritimes, respectively
- AC Parkhill and Almonte, two-row barleys adapted to Ontario and outyielding check varieties by 6–10%.

Barley DNA fingerprinting Export markets for malting barley are demanding shipments of a single variety with purity of more than 95%. Some of Canada's trade competitors offer purity levels of 97% or better. Researchers have developed an identification process, based on breeder's seed, for 125 barley cultivars that were registered in Canada in 1995. A single seed now can be identified based on DNA fingerprinting. The identification key is fully computerized and can be updated as new cultivars are released.

New corn lines Five new corn inbred lines, CO422–CO426, of diverse genetic background and superior combining ability, were released to the Canadian seed industry for commercial evaluation. CO422 is the third leafy, reduced-stature *(Lfy rd1)* inbred to be released.

Collaboration with the Indian Agricultural Program of Ontario has led to the breeding of two native corn hybrids with

- improved stalk strength
- reduced tillering
- higher yields.

Tests for corn quality Researchers have described Ontario food corn using various testing protocols to monitor corn quality for

- dry milling
- Mexican food applications.

Commercial hybrids, grown in Ontario or imported from the United States, were characterized to provide baseline quality values for food-corn hybrid development in Ontario.

Evaluation for resistance to Fusarium and other pests in corn An integral component of breeding corn for resistance to *Fusarium graminearum* ear rot is the identification of resistant genotypes. Since natural infection is not consistent from year to year, researchers artificially inoculated plants with fungal spores. Two methods were compared:

- inoculation via the silk channel
- inoculation via the kernel.

Over 3 years and two locations, only two out of 61 hybrids ranked as moderately resistant to the fungus by both inoculation methods.

In addition to the procedures already in place to screen for resistance to ear rot (*Fusarium* spp.), the European corn borer (*Ostrinia nubilalis*), and corn rootworms (*Diabrotica* spp.), the centre's corn pest resistance program has developed procedures to rapidly screen corn inbreds and hybrids for resistance to

- stalk rot (*Fusarium* spp.)
- eyespot (*Aureobasidium zeae*)
- common rust (*Puccinia sorghi*)
- common smut (*Ustilago maydis*)
- northern leaf blight (*Exserohilum turcicum*).

From a screening of 215 corn genotypes, sources of resistance to one or more pests were identified.

Transformation for Fusarium resistance Embryogenic maize cultures were transformed genetically using the wheat oxalate oxidase gene. Field trials of the new lines for *Fusarium* resistance showed one homozygous line with improved resistance to silk channel inoculation.

Molecular tools to control Fusarium resistance in corn Progress made in developing molecular tools to control *Fusarium* fungal infection of corn includes

- introduction into corn of a modified peptidyl transferase gene (*Rpl3*). The transgenic calli obtained show resistance to deoxynivalenol, a toxin secreted by *Fusarium graminearum* to facilitate infection by the fungus
- isolation from corn, and characterization, of two genomic copies of the *Rpl3* gene
- completion of the field test of a *F. graminearum* strain that is genetically altered to block production of tricothecene-type toxins (such as deoxynivalenol). The altered fungi had a decreased capacity to infect corn, confirming the role of the toxin as a virulence factor.
- isolation from corn silk, and characterization, of two genes specifically expressed in response to infection by *F. graminearum*
- isolation and characterization of the regulatory and coding regions of a gene specifically expressed in corn silk.

Prediction of plant development Researchers tested a crop architecture model on a range of corn phenotypes and found it could predict light interception by the canopy. It was successfully used to identify genotypes with superior whole plant silage yields.

A variety of thermal indices are used in North America, such as

- growing degree days
- crop heat units
- Minnesota days.

Guidelines for comparing these indices were developed to improve communication and aid comparison among regions using different thermal indices.

A general thermal index to predict corn development has been proposed, based on

- different temperature response functions for the vegetative and grain filling periods
- a constant conversion date of 1 August.

The proposed index reduced the error in predicting maturity dates to 8.2 days, an improvement of 40% over existing indices. Use of estimated hourly air temperatures further reduced the error to 5.5 days.

Nitrogen fertilization Development of reliable nitrogen (N) fertilizer recommendations has proven difficult, particularly when organic N amendments, such as manures, are incorporated. Measurement of corn N demand and soil N mineralization has demonstrated that

- manure may provide half of corn's total N requirement
- N made available after crop flowering is two times greater from manure than from inorganic fertilizers. (The 20% increase in N-use efficiency of current hybrids compared with those released 30–40 years ago results from increased N uptake by roots after flowering.)
- measurement of plant status, based on chlorophyll concentration and leaf area, has proven to be a less variable indicator of soil N deficiency through the season than fluctuating soil mineral N levels in a mesic environment.

Mapping of the oat genome A linkage map of molecular markers was developed in a new hexaploid oat population. The map locates 250 new amplified fragment length polymorphisms relative to markers identified in previous mapping studies. Genomic regions that affect quality and agronomic performance have been identified.

A broader application of this work is to associate the oat genomic map with that of evolutionarily related cereal species. Knowledge of similarities among cereal genomes will aid

- future efforts to apply molecular breeding techniques
- gene isolation and characterization.

Oat quality analysis Researchers have developed near infrared reflectance spectroscopy techniques to determine the oat groat oil and protein contents using ground, whole-seed samples. This approach avoids the time-consuming dehulling operation before undertaking quality analysis for milling oats.

New soybean varieties Three small-seeded natto type lines were released to the Canadian soyfood industry:
- X3222-B-B-74, similar in maturity to AC Colibri and AC Pinson and yielding about 10% more, compared with the natto check cultivars
- X3226-B-B-34, similar in maturity to T2653 and Micron and yielding about 7% more, compared with the natto check cultivars
- X3227-6-B-57, similar in maturity to T2653 and Micron and yielding about 9% more, with about 4% higher protein compared with the natto check cultivars.

Since the 1930s the yield of oilseed soybean varieties developed for short-season regions has improved by about 0.5% per year. As yield has increased,
- total plant leaf area has decreased
- photosynthetic rate per unit leaf area has increased.

Indicators of soybean quality A new soybean hilum color, imperfect yellow, has been described. This finding reflects the tendency for yellow hilum soybean seeds produced on brown pubescent plants to discolor, especially when the seeds develop under cool temperatures.

A number of soybean lines have been identified with increased or reduced content of sugars such as sucrose, stachyose, and raffinose. Sugar levels in the seed have a major influence on the quality of various soy foods.

Rapid water uptake is an important characteristic for soybeans used for tofu, miso, or natto. Nuclear magnetic resonance imaging was used to follow water uptake during imbibition of an intact seed. Once the embryo is hydrated, water movement seems to follow the vascularisation pathway and proceed from the centre, spreading toward the edges of the cotyledons. Various soybean seed structures will be investigated further to understand the differences observed in rate and amount of water uptake for the different varieties.

Transformation for disease resistance in soybeans White mold or *Sclerotinia* stem rot is one of the most prevalent and difficult-to-control diseases of soybean. Transgenic soybeans expressing the wheat oxalate oxidase gene were produced by *Agrobacterium*-mediated transformation. In confined field trials at five locations in eastern Canada, the transformed line had significant field resistance to white mold under both natural and artificial infection when compared with the untransformed check.

A gene from sugar beet, thought to be involved in sugar beet cyst nematode resistance, was introduced into soybean by particle bombardment. Fertile transgenic lines resulted and will be screened for resistance to the soybean cyst nematode.

Soybean gene expression Geneticists have isolated and characterized soybean genes that are expressed at different stages of seed coat development. They have also isolated soybean root specific genes by differential screening of a root cDNA library. The regulatory regions of these genes will be used to target gene expression to soybean roots.

A gene encoding a modified Bowman–Burke protease inhibitor was constructed. This gene will be used to alter the amino acid composition of soybean seed.

Partial sequences of four hundred genes expressed in cold-grown soybean leaves have been obtained. Expression analyses of cold-induced genes will be used to devise strategies to improve cold tolerance in soybeans.

New winter wheat varieties Plant breeders at the centre have produced five new winter wheat varieties:
- AC MacKinnon, a winter-hardy, high-yielding white pastry wheat with powdery mildew resistance and excellent yields in all winter-wheat-growing areas of Ontario. Its enhanced winter survival should expand pastry wheat

acreage in eastern Canada.

- AC Essex and AC Mountain, two white pastry varieties. They are high yielding and well adapted to the main winter wheat area of southern Ontario.
- AC Zorro and AC Delta, two hard red winter bread type varieties. Both exhibit much-improved winter survival. They have approximately 1.5–2% higher protein levels compared with the check cultivar Fundulea, as well as improved bread-making qualities. These varieties will permit the expansion of hard red winter bread wheat in eastern Ontario, Quebec, and Atlantic Canada.

Fusarium resistance in wheat Doubled haploid progeny from a cross between the Chinese cultivar Sumai 3 (resistant to *Fusarium* head scab) and HY368 (susceptible) were characterized in greenhouse and field tests for

- *Fusarium* symptoms
- mycotoxin (deoxynivalenol) levels.

Molecular markers showing polymorphisms between the two parents were also genotyped on the progeny. Two of these markers are associated with resistance, and place the resistance genes on chromosomes 3B and 6B. These results will lead to the development of DNA markers suitable for marker-assisted selection in wheat breeding. Similar studies have been initiated to locate resistance genes in the Brazilian cultivar Frontana.

Strains of *Triticum timopheevi* with resistance to Tanspot, *Septoria*, and *Fusarium* head scab were crossed to Canadian cultivars. Resistance was expressed in the F_1 hybrids. Up to 12 bivalents were observed at meiosis in the hybrids, indicating that adequate recombination should be occurring between the chromosomes of *T. timopheevi* and those of wheat. The genes transferred from *T. timopheevi* will supplement those present in cultivated wheat.

Wheat quality analysis An image-analysis method for wheat classification was developed based on

- color separation of digitized images
- size and shape features of the seed.

A joint project with Robin Hood Multifoods assessed several commercial Ontario red wheats for

- traditional quality traits
- performance in a variety of baked products.

Differences in baking performance confirmed that current eastern Canadian wheat quality groupings, largely based on dough functionality and traditional quality assessments, adequately describe the quality needed in a diverse baked product market.

New developments in oilseed biotechnology
Researchers have

- isolated and characterized four *Brassica* genes that promote time-to-flower in transgenic *Arabidopsis*; one is now being tested in *B. napus* and *B. carinata*
- isolated a stigma-specific gene from *Brassica*
- collaborated with the Saskatoon Research Centre to successfully field-evaluate canola transformed with a potato serine protease inhibitor against lygus bug infestation
- field-test in Ontario, canola transformed with a gene to decrease chlorophyll content in the maturing seed.

Dissection of constitutive promoter The promoter tCUP confers high levels of constitutive expression on genes in a variety of transgenic crops. Geneticists have dissected this promoter into functional regions that have been substantially enhanced individually.

Control of fungal growth Researchers have identified and characterized a bacterial isolate that can control the growth and sporulation of

- *Fusarium*
- *Alternaria*
- *Rhizoctonia*
- *Sclerotinia.*

New method to predict fate of microorganisms A laboratory method has been devised to predict the fate of microorganisms in the soil environment prior to the actual field release of genetically modified strains. Researchers collaborated with Environment Canada to validate the method by a multi-site release of a marked *Pseudomonas chloroaphis.*

Molecular diagnosis of disappearing root rot of ginseng Ginseng is becoming an important alternative crop in Ontario. Current estimated annual farm-gate value exceeds $50 million. The crop takes 5 years to mature and often suffers from yield losses of 30–40% from root rot diseases. Of particular concern is disappearing root rot, caused by the fungus *Cylindrocarpon destructans*. A collaborative project with the Southern Crop Protection and Food Research Centre (London), with external funding from the Ontario Research Enhancement Program, has shown that the pathogen strains that attack ginseng differ molecularly from those that attack other hosts, such as conifer seedlings. The ability to identify the ginseng pathogen will allow rapid molecular detection of this disease in the field, enabling farmers to harvest the root crop before extensive yield losses occur.

Bulletin describing flax fungus *Alternaria linicola* is a seed-borne fungus that causes a blight of flax seedlings in Canada and north temperate Europe. Exports of Canadian-grown flax to Europe must be routinely evaluated for the fungus. To help plant pathologists and regulatory agencies evaluate seeds, the centre has completed a bulletin with taxonomic descriptions and illustrations of this fungus.

Trichoderma identification Beneficial species of the fungal genus *Trichoderm*a are used as biocontrol agents against soil-borne crop diseases. However, one closely related strain causes the economically important green-mold disease on commercial mushrooms. The taxonomy of this genus is poorly understood and species identification is problematic. Researchers at the centre have collaborated with

- Brock University, to develop morphological and molecular techniques that allow rapid and accurate identification of this aggressive strain of *Trichoderma*
- the Centraalbureau voor Schimmelcultures, the Netherlands, to complete identification keys to, and illustrations of, 33 recognized species of the genus.

Crucifera trait genetics The electronic media offers new ways to transfer technology, allowing for both

- ready access to information
- ease of future updates.

A joint project with the Saskatoon Research Centre and the University of Manitoba has resulted in a new information product, *Cruciferae: compendium of trait genetics*. The compendium provides the first comprehensive review for the *Brassica* species and wild crucifer relatives of the genetic bases for the following traits:

- morphological
- agronomic
- physiological
- biochemical
- molecular.

It will aid Canadian plant breeders and biotechnologists in selecting traits to improve canola and related crops.

Cruciferae genetic resources Wild members of the Cruciferae family are an important genetic resource for plant breeders and biotechnologists of canola and mustard crops. The centre has completed a new electronic product on the genetic resources of the Brassicaceae or mustard family in Canada. It provides taxonomic information on 223 species, along with

- scientific and common names
- distributional data (both reference-based distributions and computer-generated maps based on ca.17 000 herbarium specimens)
- biological information on chromosome numbers
- native or introduced status in Canada
- life form
- ecology.

Brome seed identification The identification of brome species in cleaned forage seed commodities is extremely difficult, as the normal identification features such as awns and hairs are removed in processing. Microscopic features have been characterized for the seeds of

- smooth brome (*Bromus inermis*)
- meadow brome (*B. riparius*) seed.

This step will allow increased accuracy of identification and improved quality certification for export markets.

Biological control of bertha armyworm The bertha armyworm is an important pest of canola in western Canada. A 3-year project with funding from the Saskatchewan Agriculture Development Fund has evaluated the foreign parasitoid *Microplitis mediator* for enhanced biological control of the pest. More than 9000 parasitoids and parasitized host larvae were released into organically grown canola fields in central Saskatchewan.

A website also has been established to aid the identification of insect parasites of bertha armyworm (*http://res.agr.ca/ecorc/isbi/pest/berthom.htm*). Included are

- pictorial keys to species
- notes on the biology of each insect parasite
- full-color digital images.

Cutworm moth identification Cutworm moths (tribe Noctuini) are a large group of North American agricultural and forestry pests. The centre has published *The Moths of America North of Mexico* describing 169 species in 31 genera. It provides

- descriptions
- illustrations
- easy-to-use keys
- range maps.

The monograph also describes the cutworm stage for 89 species for which larvae are known. It will help taxonomists and entomology extension specialists identify species within this tribe.

Identification of Canadian casebearer species Coleophorid moths, also known as casebearers, include several agricultural pests, as well as some species that are used for the biological control of pasture weeds. An estimated half of the 200 casebearer species present in Canada are either unreported or new to science. Their geographical distributions and host plants are poorly known. Their identification remains difficult because of

- their very small size
- high species diversity
- lack of comprehensive identification tools.

The centre has now published new records of

- host plants
- distributions of 28 native casebearer species in eastern Canada and another previously undetected exotic species of European origin.

This publication provides identification illustrations to aid identification of these species.

Identification of the genus Monotoma Members of beetle genus *Monotoma* are regularly found in stored food in Canada, devaluing these products. Little is known about species native to North America, and keys to aid identifying them are not available. To address this deficiency, the centre has published a monograph with appropriate keys to the 13 recognized Canadian species of the genus.

Identification of the Lepidoptera families in Quebec The centre has published a comprehensive annotated checklist of the Lepidoptera (moths and butterflies) of Quebec. This publication, the first modern taxonomic checklist of all families of Lepidoptera for any part of Canada,

- documents the presence of 2577 species of moths, based on authoritative verification of collection specimens and cross-referencing with published literature
- notes the probable occurrence of another 278 species
- includes sections on modern Lepidoptera classification
- aids identification of new foreign species.

Aid for identifying histerid beetles Insect pests annually cause more than $100 million damage to Canadian livestock production. Beetles in the family Histeridae are important predators of pest flies associated with livestock. Entomologists have completed a book on the histerid beetles of Quebec, with

- identification keys
- information on biology and morphology.

It will assist extension specialists in addressing the problems of livestock pests.

Assessment of species diversity in the Montane Cordillera Ecozone An assessment of species diversity in the Montane Cordillera Ecozone was completed in partnership with Environment Canada, the Ecological Monitoring and Assessment Network (EMAN), and the University of British Columbia (on-line address *http://www.cciw.ca/eman-temp/reports/publications/*). This assessment

- summarizes knowledge of the occurrence and distribution of species in more than 20 diverse groups in the ecozone
- discusses changes in species diversity in response to large-scale environmental trends and local stressors caused by human activities, including agriculture.

Implementation of taxonomic information systems The Integrated Taxonomic Information System is an international taxonomic database produced through collaboration among Agriculture and Agri-Food Canada, seven United States departments and agencies, and a large number of scientific contributors. It can be used by government and the Canadian public to quickly locate information on

- crop and animal commodities
- genetic resources
- agricultural pests
- biological control agents
- diseases.

The latest improvements in the Canadian version include
- a web-based, on-line maintenance module for data contributors
- new modules to keep track of relations between species other than taxonomic ones (e.g., host–pest relationships).

Use of national reference collections The resources of the Vascular Plant Herbarium were used to provide 4422 plant identifications in 1998. The herbarium collection was expanded to include voucher material of various research studies on
- medicinal crops
- newly reported and expanding pest plants.

The Canadian National Collection of Insects and Arachnids provided for 47 689 insect identifications. The collection expanded to include 228 000 specimens from studies on insect species that are
- pests
- beneficial
- bioindicators.

New climate database Researchers have processed national climatic data, generated in collaboration with the Atmospheric Environment Service, Environment Canada. They have also prepared a new database relevant to agriculture, available on the Internet *(http://res.agr.ca/CANSIS/NSDB/ECOSTRAT/DISTRICT/climate.html)*.

The data cover 1021 ecodistricts in Canada for the 30-year period 1961–1990, and include variables for
- temperature
- precipitation
- wind
- solar radiation
- humidity
- growing degree-days
- potential evapotranspiration
- deficits.

Agricultural use of climate information A number of products have been completed that
- present the implications of climate change
- provide long-term climate information without the need to interpolate between stations or calculate derived measures.

Published assessments include reports on
- water deficits and surpluses for agriculture in Ontario
- potential impacts of climate change on agriculture in the Atlantic region
- agricultural drought in Canada
- climate input requirements of soil–crop–weather models for climate-change applications.

To improve the usefulness of climate data for the agricultural community, geostatistical interpolation algorithms using digital elevation data and other landscape parameters were evaluated. They provide better spatial resolution in areas with a sparse network of climate stations.

Revised edition of the Canadian System of Soil Classification The Canadian System of Soil Classification is the standard national reference for classification and taxonomy of soils. A third edition, published in 1998, includes
- revisions to the Cryosolic order
- a new Vertisolic order
- an improved key to soil classification.

The new edition is fully correlated with the U.S. and international soil taxonomic systems.

In a related area, a North American soil carbon map with associated databases was completed in cooperation with American and Mexican soil scientists.

Electronic availability of land and soil maps Through the centre's collaboration with Natural Resources Canada and Statistics Canada, the Canada Land Inventory–Soil Capability for Agriculture maps are now available electronically. The new electronic format will expand their use by the agricultural sector in conducting evaluations of environmental impacts and productivity potentials.

In the area of resource data application, researchers at the centre collaborated with Health Canada and the U.S. Environmental Protection Agency to develop a prototype geographic information–decision support system for the identification of similar ecological areas in Canada and the United States. This initiative is a significant first step in simplifying the testing and registration of pesticides based on land resource and socio-economic information.

Composting sewage sludge Studies on the impact of biosolid applications on soil quality have shown that composting sewage sludge and manure rich in metals has a strong influence on the extractability and exchangeability of heavy metals. This reduces the likelihood that heavy metals will move through the soil profile.

Composting sewage sludge leads to

- retention of high levels of heavy metals by strong organic matter ligands
- reduced risk of heavy metals being transferred to the food chain and water.

The mineralization of carbon and the redistribution of carbon and nitrogen during composting of manures indicate that mature compost is superior to young compost

- as a source of organic matter for soils
- for increasing potential nitrogen reserves.

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Mandate

The Southern Crop Protection and Food Research Centre (SCPFRC) and its research sites bring a long-term commitment in crop protection and food research to the agri-food industry in southern Ontario.

The centre's mandate is to

- develop alternative and environmentally acceptable technologies for the protection of tree fruits, vegetables, field, and ornamental crops against disease and insect pests
- develop alternative crops and sustainable management practices for coarse-textured soils
- determine the impact of sustainable agricultural practices on soil and water quality
- conduct research on chemical and microbial food quality, and on the impacts of change toward more sustainable production and processing practices on food quality.

Resources

Multidisciplinary teams conduct the research programs of the Southern Crop Protection and Food Research Centre (SCPFRC) at four locations. The centre's headquarters are located in London, Ont., on Sandford Street and at the Siebens Drake Research Institute at the University of Western Ontario. The Food Research Program is located at the University of Guelph. Research facilities are also located at Vineland, Ont., and Delhi, Ont. The centre's total land base of 110 ha comprises

- 25 ha in London
- 25 ha in Vineland
- 60 ha in Delhi.

In 1997–1998, when the achievements presented in this report were completed, the centre spent $13.9 million through their operating budget, $3.5 million from the Matching Investment Initiative, and $0.5 million from other special programs. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

The Ontario Research Enhancement Program, which is providing $4 million over two years (1997–1999) is administered through SCPFRC. The development of a national internet website, ManureNet, at SCPFRC is being funded through the Hog Environmental Management Strategy of Agriculture & Agri-Food Canada (AAFC).

Achievements

- *Staff award and honors*
- *MII - Sprayable pheromone for controlling moth*
- *Isolation of the soybean peroxidase Ep gene*
- *Genetic mapping of soybean gene*
- *Molecular genetic analysis of soybean seed coat*
- *Isolation of stevia genes*
- *Patents for three stevia clones*
- *Discovery of novel transposon linked to disease resistance*
- *New disease therapies*
- *Control of bacterial toxin production*
- *New cultural method for ginseng*
- *Medicinal herbs research*
- *Clonal propagation of medicinal plants*
- *Method to measure ginsenosides*
- *Biocontrol of foliar diseases of ginseng*
- *Control of fungus in ginseng*
- *Effective seeding density for ginseng*
- *Study of ginseng replant failure*
- *Tomato tolerance to Verticillium wilt*
- *Reduced incidence of potato disease with soil amendments*
- *Molecular characterization of Verticillium dahliae*
- *International study on Verticillium dahliae*
- *Clone of gene encoding GABA transporter*
- *Biocontrol for tomato transplants*
- *Management of resistance to potato beetle*
- *Development of fire blight resistance in*

pears

- *Integrated control of greenhouse pests*
- *Control of crown gall disease in dormant nursery stock*
- *Control of brown rot on stone fruits*
- *Herbicide removal by earthworms*
- *Microbial biocontrol of transplant diseases*
- *Reduced soil erosion with rye cover crop*
- *New method to separate soybean isoflavones*
- *New methods for conjugated linoleic acid*
- *Analysis of cheese using electron microscopy*
- *Food analysis with electronic nose*

technology

- *Improved pasteurization*
- *Study of bacterial toxins*
- *New method to isolate antibacterial viruses*
- *Salmonella control in poultry*
- *Bacterial typing*
- *Bacterial modeling*
- *Studies on cereal ß-glucans*
- *Value-added crop processing*
- *Characterization of polysaccharide gums*
- *Studies of soybean carbohydrates*

Staff award and honors Dr. Bruce Bowman received a 1998 Research Branch Award in recognition of establishing a web page for the centre.

Ms. Stephanie Hilton received an Agcellence Award in recognition of her efforts with the Royal Winter Fair.

MII - Sprayable pheromone for controlling moth Researchers compared the efficacy of three treatments in controlling the grape berry moth, *Endopiza viteana*, in commercial vineyards in the Niagara peninsula during 1997 and 1998:

- 3M Sprayable Pheromone (3M Canada Company, London, Ontario, Canada)
- Isomate® GBM pheromone dispensers (Pacific Biocontrol, Vancouver, Wash., U.S.A.)
- organophosphorus insecticide.

The sprayable pheromone provided control of the moth equal to that of the other two treatments. The ability to apply pheromone using conventional pesticide application equipment should facilitate the widespread use of this environment friendly pest control technology.

Isolation of the soybean peroxidase Ep gene Plant peroxidases are enzymes used commercially in

- diagnostics
- food processing
- manufacturing.

Many of the cultivated soybean varieties accumulate large amounts of peroxidase enzyme in the seed coat. These high-peroxidase types carry the dominant *Ep* gene. The cloning of this gene completes work begun more than 30 years ago by researchers at Harrow. It has proceeded from initial description of the gene to

- its identification
- the determination of the complete DNA sequence
- cause of mutant alleles.

The soybean peroxidase enzyme is an important value-added trait because it provides new uses and markets for the hulls. Isolation of the gene encoding this enzyme opens up further possibilities for adding value to soybeans. The *Ep* gene sequences may be used to select varieties that overproduce the enzyme, or to express entirely new proteins in the seed coat.

Genetic mapping of soybean gene *Phytophthora sojae* is a destructive pathogen that causes root rot of soybean. Research in collaboration with the Noble Foundation (Ardmore, Oklahoma) and the Greenhouse and Processing Crops Research Centre (Harrow, Ont.) has resulted in a high-resolution genetic map encompassing the most important root-rot resistance gene currently in use, *Rps1*-k. The *Rps1*-k gene is integrated into many widely grown soybean cultivars. Genetic mapping of this gene will allow for early and direct selection of *Phytophthora*-resistant plants in cultivar-development programs.

Molecular genetic analysis of soybean seed coat Seed coat tissues of soybean constitute 4–5% of the seed mass. The seed coat determines, or contributes to,

- the appearance and hardness of the seed
- resistance to seed-borne diseases
- composition, texture, and nutritional value of

food and feed products derived from the seed.

Molecular genetic analysis of soybean seed coat has identified genes controlling
- seed luster
- surface protein composition.

Isolation of stevia genes Copalyl diphosphate synthase and kaurene synthase genes are involved in
- the biosynthesis of the sweet glycosides of stevia
- the production of the plant hormone gibberellic acid.

Their expression and regulation could give scientists and biotechnologists interested in plant hormone biosynthesis the ability to control plant height, a significant factor in crop lodging.

Patents for three stevia clones Three stevia clones with unique sweet glycoside compositions were awarded U.S. plant patents. These lines allow simple extraction and purification of individual sweet glycosides for use in precise blends.

Discovery of novel transposon linked to disease resistance Retrotransposons are mobile genetic elements that make up a large part of most plant genomes. Cloning and characterization of a randomly amplified DNA fragment led to the discovery of a new retrotransposon that can be used to isolate the disease-resistance gene. The gene
- will be useful for understanding host–parasite interaction
- may be used to confer resistance on other crop species, such as carrot.

New disease therapies Researchers are using a platform based on low-alkaloid tobacco, used for the production of pharmaceutical proteins and oral vaccines, to develop therapies for
- autoimmune diseases of humans
- infectious diseases of swine.

Control of bacterial toxin production Coronatine is a chlorosis-inducing phytotoxin produced by
- the tomato and crucifer pathogen *Pseudomonas syringae* pv. *tomato*
- the soybean pathogen *P. syringae* pv. *glycinea.*

How the gene cluster that controls toxin synthesis is regulated is unknown.

Using *cor::inaZ* marker exchange derivatives of *P. syringae* pv. *tomato* DC3000 that are ice nucleation-active, researchers determined that coronatine gene expression, first detected 4 h after inoculation, was
- highest in cabbage, tomato, and soybean
- lowest in melon and cucumber.

Based on high-performance liquid chromatography analyses and bioassays, the active components in crude tomato leaf extract and intercellular fluid were
- malic acid
- citric acid
- shikimic and quinic acid (both minor).

Only shikimic and quinic acids had activity at concentrations below 0.1 m*M*. Their activity was enhanced 10-fold by the addition of glucose. None of the plant phenolics screened affected coronatine gene expression.

New cultural method for ginseng Tissue culture techniques have been developed, adapted, and improved to establish a new method for cloning ginseng plants. This process, sometimes called artificial or synthetic seed production, produced propagation or planting units equivalent to a 1-year seedling at the time of planting.

Field trials at our Delhi site are under way to compare the performance of plants derived from tissue culture with that of plants from seeds. The program, supported by the Ontario Research Enhancement Program, is expected to provide alternative technologies to accelerate the genetic improvement of ginseng germplasm for the regions' growers.

Medicinal herbs research The centre has initiated new programs on improving the germplasm of
- St. John's wort (*Hypericum perforatum*)
- valerian (*Valeriana officinalis*).

We have also developed new cultural practices for feverfew (*Tanacetum parthenium*).

In response to requests from the industry and general public, a website on medicinal herbs research programs at the centre was established (http://res.agr.ca/lond/pmrc/study/newcrops/ncweb.html). The site provides
- a review of programs on herbs, such as ginseng, stevia, and evening primrose
- background information on new projects on goldenseal, feverfew, valerian, St. John's wort.

etc.

Clonal propagation of medicinal plants Feverfew (*Tanacetum parthenium*), a herbal remedy for migraines, is produced commercially in the sandy loam soils of southern Ontario. Field trials of clones of selected feverfew lines propagated from tissue culture have shown that micropropagated lines maintain their high level of parthenolide (measurable active component) content under field-production conditions.

Compared with lines of unselected seed that are used for commercial planting, selected lines

- contained up to six times more parthenolide
- maintained a consistently high level among the clones tested.

These new technologies will provide new options for growers to improve their efficiency and product quality.

Method to measure ginsenosides Two new methods have been developed to determine ginsenosides in ginseng:

- a high-performance, reversed-phase liquid chromatographic determination
- an indirect determination of the malonyl-ginsenosides.

Biocontrol of foliar diseases of ginseng
Researchers have isolated three pathogens from ginseng stems and straw mulch, but not from soil:

- *Alternaria panax*
- *A. alternata*
- *Botrytis cinerea.*

This finding indicates that microbial agents (bacteria and fungi) that destroy overwintering inoculum are in the soil. Inoculum in the ginseng stems and straw not incorporated into the soil seems to escape microbial degradation.

Saprophytes isolated from the soil, stems, and straw included two bacteria and seven fungi. Five of these inhibited mycelial growth of *A. panax*.

Control of fungus in ginseng Researchers investigated the association between ginseng grown in monoculture and vesicular–arbuscular mycorrhizae (VAM). They found that

- fumigation of ginseng gardens in the fall significantly decreased the level of mycorrhizal fungal inoculum (MFI)
- VAM colonization of ginseng increased from early summer and then decreased from August for all plants except first-year plants growing in a second-year garden, possibly because of elevated MFI levels
- arbuscular colonization peaked in August and was greater than hyphal colonization until just before the end of September
- root-to-shoot ratios increased over the entire season, indicating the partitioning of most of the reserves into the tap root
- phosphate amendments had little direct effect on ginseng growth but reduced mycorrhizal colonization by 10% at the highest phosphate level compared with the control. Greater mycorrhizal colonization of the control may have increased root dry weight, and cumulative lateral root length, implying that increasing phosphate amendments may decrease growth of first-year ginseng.

Effective seeding density for ginseng Researchers established field trials to determine the effects of seeding density on

- yield of ginseng
- ginsenoside concentration in roots.

As seeding density increased from 50 seeds to 240 seeds per square metre,

- the number of roots at harvest increased
- the total dry root weight increased
- the total amount of ginsenosides per gram of root was not affected
- amounts of the ginsenosides Rc and Rb_2 slightly, but significantly, increased.

Differences between seeding rates of 50 and 140 seeds per square metre generally were greater than those between rates of 140 and 240 seeds per square metre. Thus, there appears to be little advantage in using seeding densities greater than 140 seeds per square metre.

Study of ginseng replant failure Sites of old ginseng plantations are generally avoided for new gardens because of reports of crop failure when sites are replanted. To determine the cause of replant failure, soils from both old ginseng sites and plots not previously cropped to ginseng were collected and

- placed in a series of microplots under wood-lathe shade
- treated with a commercial fumigant
- later planted with ginseng seeds.

Plants that emerged from “old garden” soils quickly developed a yellowed, stunted appearance typical of replant failure. The fungus *Cylindrocarpon destructans* was the pathogen most frequently isolated from the stunted, yellowed plants. This finding suggests that *Cylindrocarpon* may be an important factor in the replant problem.

Tomato tolerance to Verticillium wilt The plant growth hormone 2,4-epibrassinolide was shown to induce tolerance to *Verticillium* wilt in tomato. Studies are in progress to determine how this tolerance is induced.

Reduced incidence of potato disease with soil amendments Researchers set up field experiments on two commercial potato farms near Alliston, Ont., to examine the impact of various soil amendments on the incidence of
- *Verticillium* wilt
- potato scab.

Amendments were incorporated in 1996 and crops planted for 3 years. Organic materials containing a high amount of nitrogen, such as soymeal, meat and bone meal, and chicken manure, were effective. They
- reduced *Verticillium* wilt by 70–95% for 2 years in both fields, but not in the 3rd year
- reduced scab to near zero in both fields in the first season, and to 50% in one field in the second season; no effect was seen in the 3rd year
- reduced plant pathogenic nematode populations to zero for 2 years in both fields.

Other amendments studied included:
- solid cattle manure and liquid swine manure, which reduced *Verticillium* wilt in one field only, but not the same field
- swine manure, which reduced the amount of potato scab in both fields in the first season and in one field for three seasons
- calcium carbonate (lime), which dramatically increased the incidence of *Verticillium* wilt and potato scab in both fields for all 3 years.

Marketable yield improvements were found with the products high in nitrogen and with swine manure.

Molecular characterization of Verticillium dahliae Race 2 isolates of the pathogen *V. dahliae* that predominate in Essex County tomato fields were found to be closely related to isolates associated with potato production. Potato production in this county may thus contribute to the accumulation of the race 2 pathotype.

International study on Verticillium dahliae Researchers compared methods used to measure populations of the pathogen *V. dahliae* in soils and found that all were inadequate. Some laboratories produced comparable numbers, but an equal number obtained values that were 10 times above or below the expected value. The study identified which procedure is currently superior.

Clone of gene encoding GABA transporter The neurotransmitter γ-aminobutyric acid (GABA) is the primary inhibitory transmitter molecule in the central and peripheral nervous systems of insects. Geneticists have cloned an insect gene that encodes a membrane transporter for GABA and expressed the protein in cultured insect cells. The resulting expression system is useful in applying high-throughput screening methods to the identification of compounds capable of blocking this critical activity. The system is being transfered to industry where it will provide an innovative approach to the generation of pest-control products based on new specificities.

Biocontrol for tomato transplants Naturally occurring polyene antibiotics are the substances found in new actinomycetous biocontrol agents that suppress damping-off and root rot in tomato transplants. These agents protect plants against *Rhizoctonia solani* and other pathogenic fungi when applied to
- tomato seed
- potting medium.

This biocontrol technology will
- reduce plant losses
- improve transplant quality
- increase yields of tomato and other transplanted vegetable and horticultural crops.

Management of resistance to potato beetle Pests may become less susceptible to pesticides over time. Researchers measured the susceptibility of Colorado potato beetles populations from tomato- and potato-

growing regions in Ontario, to
- track changes over three growing seasons
- help develop a strategy for managing resistance.

Leaf dip bioassays were used to distinguish between susceptible and resistant strains of beetles. Among the findings,
- beetles receiving direct contact applications developed no resistance
- the number of beetles recovering from the initial dose rose in the 3rd year, which may indicate changes in the populations.

Susceptibility to chlorfenapyr and imidacloprid, effective new insecticides for control of Colorado potato beetle, was measured in 29 representative populations from Saskatchewan to Prince Edward Island. Critical components of efficient strategies for mananaging resistance for this troublesome pest are
- baseline data on effectiveness
- a measure of susceptibility–variability.

Development of fire blight resistance in pears Fire blight, a bacterial disease of pears, is the main constraint to increased production of this fruit in Ontario. Only one chemical is registered for control of this disease, and timing of application is critical. Geneticists are using biotechnological techniques to develop commercial pear cultivars that are resistant to fire blight. They expect that a population of transgenic plants will be developed within 3 to 5 years, and grower trials will be initiated within 10 years.

Integrated control of greenhouse pests Agreements to commercialize a food-grade product for control of the western flower thrips and other pests of greenhouse crops are being finalized. The product acts physically, rather than chemically, to greatly reduce
- feeding
- egg laying
- flight
- virus acquisition and transmission prior to induced mortality for all life stages.

The product
- may be applied to plants, floors, and benches
- is nonhazardous to workers and the environment
- is compatible with most biocontrol strategies.

Control of crown gall disease in dormant nursery stock Heat treatment is an effective way to reduce levels of crown gall disease in dormant grapevine nursery stock. In 1995, a commercial-scale heat-treatment facility was constructed by Euro Nurseries Inc., to heat-treat all nursery stock for the control of
- *Phylloxera*
- nematodes
- crown gall.

In 1998, no adverse effects of heat treatment were evident in any variety but Merlot after a season's growth in the field. Heat-treated varieties
- often showed earlier bud break
- contained no pathogens.

Pre-soaking vines for 48 h before heat treatment
- improved heat conduction
- reduced the length of time necessary for heat treatment.

In 1998, collaborative trials were set up with the major nurseries in Ontario to evaluate heat treatment of a wide selection of grapevine varieties, which will be maintained under different growing conditions. Vines will be monitored for crown gall disease over 4 to 5 years after planting.

Control of brown rot on stone fruits In collaboration with the Ontario Tender Fruit Producers' Marketing Board, researchers have identified microbes isolated from orchards in southern Ontario as potential biocontrol agents for the control of brown rot in peach. In 2-year orchard trials, peach fruit rot at harvest was significantly reduced by
- preharvest applications of one of the biocontrol agents along with a foliar fertilizer containing calcium
- various postharvest treatments with the biocontrol agents.

Herbicide removal by earthworms Earthworms process large amounts of soil as they burrow. This activity
- moves herbicide residues from the soil surface to deeper levels

- accelerates herbicide breakdown in soil.

This phenomenon is not yet taken into account in models predicting pesticide movement and dissipation in soils.

Microbial biocontrol of transplant diseases Two soil-borne pathogens, *Rhizoctonia solani* and *Fusarium oxysporum* f. sp. *radicis-lycopersici* (*FORL*), cause damping-off and seedling rot diseases in tomato plug transplants. Researchers evaluated the commercial biocontrol agent Mycostop® (*Streptomyces griseoviridis* K61) and a new bacterial agent for suppression of these pathogens.

These bacteria were effective under greenhouse conditions as pre- and post-infection treatments using three delivery methods:

- seed coating
- potting medium amendment
- potting medium granular amendment.

In general, researchers found that .

- pre-infestation treatments of bacterial biocontrol agents gave significantly greater protection to seedlings than post-infestation treatments
- Mycostop was more effective in suppressing *FORL* damping-off than *Rhizoctonia* damping-off
- formulation as alginate-clay pellets or seed coatings supplemented with organic nutrients improved the survival of the bacteria and their effectiveness in suppressing tomato diseases.

Reduced soil erosion with rye cover crop Aerial overseeding of cereal rye into standing corn was successfully demonstrated on a pilot scale in the Big Otter Watershed in a collaborative project with Long Point Region Conservation Authority. The rye cover crop reduces soil erosion and nitrate movement to groundwater.

New method to separate soybean isoflavones
Isoflavones in soybeans are being promoted as chemopreventative agents for a number of degenerative diseases, such as cancer. To assist in the evaluation of value-added benefits of isoflavones in foods, researchers developed a high-performance liquid chromatography method to separate major isoflavones in free and conjugated forms. They found that

- grinding of soybeans improves removal of isoflavones from the matrix
- soy extracts are more potent inhibitors of cytochrome P-450 than are some herbal teas.

New methods for conjugated linoleic acid
Conjugated linoleic acid (CLA) has been reported to protect against cancer and atherosclerosis by decreasing body fat while increasing muscle and bone mass. Researchers

- developed methods to separate and characterize CLA isomers in natural products
- confirmed the identity of a previously unrecognized CLA isomer in milk, cheese, beef, human milk, and human adipose tissue
- used new methods to determine the distribution of CLA in pigs
- found that feeding CLA to pigs improved carcass composition by reducing fat.

Analysis of cheese using electron microscopy
Electron microscopy was valuable in differentiating the rheology, texture, and microstructure properties of processed cheese analogues incorporating fat substitutes. Protein fat substitutes and polysaccharide-based fats are distinguishable from each other in processed cheese. Micrographs of negatively stained bateriophages were obtained for a forthcoming study of their characterization.

Food analysis with electronic nose technology An electronic nose was used to detect and characterize the aroma profiles of various foods and bacteria. The aroma profiles were then used to determine attributes associated with

- good-quality raw and finished products
- detection of food spoilage by microbial and chemical agents.

Improved pasteurization Researchers carried out several studies of thermal processing to eliminate or reduce pathogens in liquid food. They

- developed a predictive model for heat inactivation of *Listeria* spp. in milk and simulated ice-cream
- initiated a study for the Canadian Food Inspection Agency and cider producers, to develop an effective method for pasteurizing cider, in which toxigenic *E. coli* O157:H7 has

recently been detected

- tested a radio frequency (RF) source on a pilot-plant scale for its ability to pasteurize up to 80°C. An RF-based system of high-temperature short-time pasteurization is expected to be energy efficient, clean, and straightforward.

Study of bacterial toxins Isolates of *E. coli* O157:H7 producing *Shiga* toxin were obtained from various sources and characterized by comparing the electrophoretic band profiles of DNA digested with restriction enzyme. The influence of bacteriophage-induced cell lysis on the release of *Shiga* toxin was evaluated.

New method to isolate antibacterial viruses Growing resistance to antibiotics poses a serious threat to the control of food-borne pathogens. The problem has renewed interest in alternative antibacterial agents. Bacteriophages (viruses of bacteria) have previously been used as antibacterial therapy with some success. Researchers

- developed a method for isolating bacteriophages from water-purification plants
- tested the efficacy of these bacteriophages against virulent types of bacteria.

Salmonella control in poultry Methods of detecting *Salmonella* in poultry facilities were compared. A new impedance detector proved more sensitive and selective than other methods. This economical new technology is now available to the poultry industry.

Bacterial typing Bifidobacteria, a group of probiotic bacteria that live in the digestive tract, are potentially beneficial and useful for suppressing *Salmonella* in poultry. Geneticists have

- tested isolates for repeated DNA sequences, including insertion elements
- screened these sequences for their usefulness as diagnostic probes
- used the resulting DNA hybridization profiles to differentiate between species and strains of bifidobacteria isolated from chickens.

Bacterial modeling Mathematical models are used to predict growth, survival, and deactivation of bacterial cells in foods under various conditions. Researchers developed models and used them to predict

- the survival and acid tolerance of various serotypes of *E .coli*
- the survival of *E. coli* in mayonnaise.

They also mathematically defined the lag phase of growth of *Listeria monocytogenes.*

Studies on cereal ß-glucans Oat products can lower serum cholesterol levels, and on this basis a health claim (for lowering risk of heart disease) has been allowed in the United States. The viscosity of oat ß-glucan, an active polysaccharide component, in the gastrointestinal tract may be required for effectiveness. As well, viscosity and other rheological characteristics

- are important to food texture
- may reduce palatability
- are the basis of problems caused by ß-glucan in the malting and brewing industry.

Viscosity is controlled by

- hydration (solubility)
- structure
- molecular weight.

The centre's carbohydrate group has continued to work on methods to evaluate these characteristics and track them through the gastrointestinal tract. Some studies included work on

- digestibility of oat ß-glucan
- development of novel bran fractions enriched in dietary fibre, including ß-glucan, that may have application as novel food ingredients
- wheat ß-glucan, which differs from oat and barley ß-glucan in ways that may relate to solubility and the ability to form gels
- pure tri- and tetra-saccharides that are produced by enzyme action on ß-glucan.

Value-added crop processing Researchers have developed a method to extract nonstarch polysaccharides (NSP) from preprocessed wheat bran samples. At 4°C, the NSP formed a gel that could be reversed under heat. Rheological measurements were made to determine

- gel properties
- thermal stability.

This type of gelling behavior, of potential commercial value, is not known to have been previously reported in cereal NSP.

Barley is a potentially rich source of ß-glucan and may more readily mill to ß-glucan-rich fractions. The potential for novel food applications of barley is high and is now being investigated.

Characterization of polysaccharide gums
Polysaccharide gums play an important role in food systems as thickeners and stabilizers. They improve food-product characteristics such as

- texture
- shelf life
- quality of food products, such as processed meats and salad dressings.

Researchers have developed rheological methods to characterize polysaccharide gums from

- solutions
- foods
- nonfood systems.

Studies of soybean carbohydrates One of the most important attributes of a soyfood soybean is its ability to absorb water before steaming or boiling. Some soybean varieties have a significant share of "stone seeds" that will not soak up water and cause problems in processing. A detailed investigation of the cell wall carbohydrates of the separated seed coat and cotyledons from several varieties of soybeans is being completed. There are early indications of intervarietal differences in carbohydrate composition. However it is not yet clear if these differences can be attributed to differences in water uptake.

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Clonal Genebank M. Luffman, M.Sc.
Clonal Genebank R. Michelutti, M.Sc.
Soil physical properties W.D. Reynolds, Ph.D

Soil and water management C.S. Tan, Ph.D.
Soil microbiology E. Topp, Ph.D.
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Soil root zone interaction T.Q. Zhang, Ph.D.

Mandate

The Greenhouse and Processing Crops Research Centre (GPCRC) develops methods for improving the productivity of

- greenhouse vegetable crops
- field vegetable crops
- oilseed and protein seed crops.

In addition, it conducts research in Ontario soils to

- develop best management practices
- improve quality
- characterize physical and chemical attributes.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $8.4 million through their operating budget, $2.7 million from the Matching Investment Initiative, $174 thousand from other special programs, and $21 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services. The centre houses the Canadian Clonal Genebank. Field operations occur at:

- the main centre and Ridge field site, covering 131 and 21 ha, respectively, of representative sandy loam soils
- the Hon. E.F. Whelan field site in Essex County (86 ha), which has Brookston clay soil (in August 1998 the department purchased a 19-ha farm west of this site for soils research; a section of this land had been rented for 30 years for studies in sub-surface drainage and long-term tillage).

The centre shares office and laboratory space with extension specialists of Ontario's Ministry of Agriculture, Food and Rural Affairs.

Achievements

- *Staff awards and honors*
- *MII - High impact with industry*
- *Control of anthracnose fruit rot*
- *Biological control agent for tomato pinworm*
- *Work of the Clonal Genebank*
- *Improved tomato production with a closed hydroponic system*
- *Colored plastic mulches for fresh market tomato production*
- *Crop productivity and soil-, water-, and air-quality*
- *New bean cultivars*
- *Enhanced yield of processing tomato with fertigation and irrigation*
- *Developments in field-crop breeding*
- *New medium for studying greenhouse cucumber disease*
- *Improved greenhouse engineering*
- *Commercialization of greenhouse software*
- *Reduced growth of field crops with high humidity*
- *Printing of symposium proceedings*
- *New greenhouse facilities*
- *New version of weed-control software*
- *Plant biotechnology*
- *Control of pythium root rot*
- *New weed control registered*
- *Pesticides' residual toxicity*

- ***New technique to determine disease resistance***
- ***New technique to measure 3-D plant growth***
- ***Soil and water management***
- ***Improved resistance to soybean cyst nematode***
- ***Tomato fruit dehydration***

Staff awards and honors Ms. M. Luffman and Ms. J. Blackburn received an Agcellence Award in recognition of their contribution to the agri-food sector.

Dr. T. Papadopoulos received an Agcellence Award for accomplishments in leadership.

Ms. J. Blackburn and Mr. R. Tiessen received a Research Branch award for their efforts in first-aid techniques applied to an injured worker.

Dr. D. Buzzell received a Research Branch award in recognition of his outstanding leadership in research, development, and technology transfer.

Dr. S. Park was awarded an honorary life membership by the Canadian Seed Grower's Association for his activities in plant breeding and technology transfer.

Dr. A. Hamill received the Essex County Associated Growers Award of Merit for his contribution to the growers of Essex County.

MII - High impact with industry In response to a request by the vegetable sector that included growers and major food processors, the centre and the University of Guelph had a project funded by the Ontario Tomato Research Institute under the Matching Investment Initiative (MII). Deliverables of the project include

- development of new processing tomato lines with improved disease resistance
- better production characteristics for use by public and private plant breeders in release of commercial tomato varieties.

Control of anthracnose fruit rot Anthracnose fruit rot is a severe disease problem in field tomato. Research shows that at least 15 distinctive biotypes of *Colletotrichum coccodes* exist in Ontario. These biotypes

- have different virulence and cultural characteristics
- are stable and can overwinter in Ontario.

The results suggest that the best way to control this disease is by breeding for disease resistance using a major gene.

- ***New method to improve transplants quality***
- ***Optimal weed control***

Biological control agent for tomato pinworm Parasitic wasp *Trichogramma pretiosum* shows potential in cage trials as an effective control measure for tomato pinworm on greenhouse tomatoes. This wasp attacks the egg stage of the host. Recommended parasite–host introduction rates are 1:1 to 10:1.

Work of the Clonal Genebank The current plant collection includes various land areas under

- *Fragaria* (224 accessions)
- *Rubus* (98)
- *Ribes* (85)
- *Samucus* (13)
- *Malus* (681)
- *Pyrus* (69)
- *Prunus* (161).

Work at the genebank includes

- the collection of preliminary descriptor data on the indigenous *Fragaria* and *Rubus* collections
- cryopreservation of dormant pear buds using techniques developed for apple
- collection and propagation of 17 local Mission pear accessions, and addition of these to the genebank collection
- filling of 14 requests for tree fruit germplasm, involving 46 accessions and 965 units
- use of the enzyme-linked immunosorbent assay technique on *Prunus* fruit trees and *Fragaria* and *Rubus* small fruit to determine the presence of some viruses of concern, as part of the Canadian Clonal Genebank Virus Indexing Program.

Improved tomato production with a closed hydroponic system Compared with tomatoes grown in an open hydroponic system, those grown in a closed rockwool system with optimal nutrient feedings showed

- similar total fruit yield and as good, or better,

fruit quality
- less root disease
- later senescence of foliage.

The centre has recommended that the greenhouse industry switch tomato production from the common open rockwool system to the more environmentally acceptable closed system.

Colored plastic mulches for fresh market tomato production Field trials were used to evaluate the effects of 12 colors of soil-level plastic mulches on insect pest incidence and plant productivity in fresh market tomatoes. Certain colors of mulch
- repelled insect pests
- increased plant growth
- promoted early yield of tomatoes.

Crop productivity and soil-, water-, and air-quality Researchers have designed a laboratory study of soils under long-term fertilization and crop rotation to examine the inter-relationships of
- soil carbon fractions
- denitrification capacity.

They have also developed a method to evaluate how red clover accelerates the decomposition of wheat straw residue. This process can improve the subsequent emergence and yield of corn.

New bean cultivars The centre has registered a new white bean cultivar, AC Compass, and released it exclusively to a private seed dealer–distributor in Ontario. Two pinto bean cultivars, AC Pintoba and AC Burrito, were registered and released exclusively to two different firms in Manitoba.

AC Compass and AC Pintoba have
- high yield potential
- erect plant type
- medium maturity
- resistance to bean common mosaic virus race 1 (AC Pintoba is also resistant to virus 15).

AC Burrito has
- early maturity
- erect growth habit
- good yield as an early cultivar.

Enhanced yield of processing tomato with fertigation and irrigation Precise timing of water and fertilizer application (through drip tubes) during the growing season for processing tomato enhanced tomato yields dramatically in field trials in southwestern Ontario.

Developments in field-crop breeding Researchers have advanced crop breeding by
- identifying a molecular marker associated with phytophthora root rot tolerance
- working to identify molecular markers associated with white mold tolerance
- developing a system to measure the protein composition of different soybean lines
- developing lines with different protein profiles and evaluating them for functional and processing qualities.

New medium for studying greenhouse cucumber disease The centre has developed a highly selective medium useful in studying the epidemiology and control of a major disease of greenhouse cucumber, *Penicillium* stem rot, caused by *Penicillium oxalicum.*

Improved greenhouse engineering Researchers improved greenhouse conditions by
- developing Ethernet-compatible communication software to connect climate-control and management computers
- installing an ultra-low nitrogen oxide, direct-contact combustion boiler for high-efficiency heating and CO_2 enrichment of greenhouses.

Commercialization of greenhouse software Two software packages, Harrow Greenhouse Manager and Enerpass for Greenhouses, use an interactive holistic approach to assist growers in decision making for
- integrated management of greenhouse vegetable production
- simulated greenhouse energy use.

Both software programs have been licensed for distribution with a private firm in Ontario.

Reduced growth of field crops with high humidity Researchers found that frequent daily episodes of very high humidity during the growing season reduced yields of processing tomato. In Essex county of southwestern Ontario, such humidity conditions occur about once every 30 years.

Printing of symposium proceedings The proceedings of the International Symposium on

Growing Media and Hydroponics, held in Windsor, Ont., in May 1997, were edited and printed by the International Society for Horticultural Science. The two-volume proceedings include 98 manuscripts.

New greenhouse facilities The centre has commissioned new state-of-the-art greenhouses for vegetable research. The new complex includes 16 compartments of double polyethylene and four compartments of glass, totaling 3200 m^2. The 4.3-m-high greenhouses are equipped with

- computerized environment and fertigation control
- a unique high-efficiency boiler
- shade curtains
- evaporative cooling
- fogging
- screened vents.

These greenhouses will facilitate advanced studies in cooperation with industry partners in the areas of

- greenhouse vegetable physiology and management
- pest and disease control
- greenhouse environment
- energy use.

A variety of projects are already under way.

New version of weed-control software ONTARIO HERB is a decision-support software for postemergence weed control in corn and soybeans. Researchers have developed a new version, named HADSS (Herbicide Application Decision Support System), which

- is WINDOWS based
- evaluates the net benefit of options for preemergence and postemergence control
- includes information on managing herbicide resistance.

Plant biotechnology A molecular biology laboratory was established to develop molecular markers for soybean and common bean breeding programs. Markers developed were

- SSR (simple sequence repeat) markers for soybean and common beans
- a SCAR (sequence characterized amplified region) marker associated with resistance to common bacterial blight in common beans
- SSR markers associated with tolerance of soybean to phytophthora root rot.

Control of pythium root rot Pythium root rot is the most severe disease in greenhouse tomato and cucumber. Researchers found that, compared with open cultural systems, closed systems

- have less pythium root rot because of the higher activity of microbial bioagents
- reduce pollution of the environment by nutrients
- reduce fertilizer cost
- reduce disease
- are more profitable.

New weed control registered The centre has registered rimsulfuron (Prism) for the control of a major new weed pest, hairy nightshade, in processing tomato.

Pesticides' residual toxicity Only pesticides that can be successfully integrated with biological control agents should be used in greenhouse pest management. In greenhouse trials in which biocontrol insects were exposed to 4-day-old residues of two pesticides, it was found that

- avermectin b1 was compatible for use with predacious mites *Amblyseius cucumeris, A. degenerans,* and *Phytoseiulus persimilis*, as well as a parasitoid *(Dacnusa sibirica)*
- pyridaben was compatible with only *D. sibirica* and *A. cucumeris.*

New technique to determine disease resistance Researchers have developed a new laboratory screening technique to determine the resistance of soybeans to *Sclerotinia* stem decay. Transgenic soybeans from the Eastern Cereal and Oilseed Research Centre and plant introductions from Asia were screened and determined to be resistant. The technique will permit more rapid development of varieties.

New technique to measure 3-D plant growth A simple, yet sensitive, technique has been developed to measure 3-D seedling growth. This technique uses a mirror and a charged couple device (CCD) camera. It is precise and overcomes the measurement errors reported for techniques that use only a mirror.

Soil and water management Researchers found that plant and root growth of both soybean and common bean were severely restricted in dry, compacted soil.

The effects of reduced water supply were more severe in

- highly compacted soils
- clay loam, compared with sandy loam soils.

An Artificial Neural Network Model was developed with McGill University to simulate water flow under conditions of subsurface drainage and subirrigation. This model can effectively simulate flow processes without a large number of input parameters.

Improved resistance to soybean cyst nematode The centre has cooperated with private seed breeders and public institutions to support a soybean variety resistant to soybean cyst nematode (SCN). Several resistant varieties produce yields 3–10% greater than those of conventional varieties.

Results from a 4-year farm study indicate that the SCN population in resistant soybeans was reduced when the soybeans were grown in rotation with a nonhost crop (e.g., corn). SCN populations were reduced by

- 30–50%, when soybeans followed 1 year of nonhost crop
- 55–65%, after 2 years of nonhost crop
- 75–86%, after 3 years of nonhost crop.

Tomato fruit dehydration Osmotic dehydration can be a cost-effective technique for removing at least half the water from tomato fruits in a relatively short time (e.g., 4 h), while retaining the fresh appearance and structure of the fruit.

New method to improve transplants quality
Researchers held back transplant growth in the greenhouse by

- adjusting the water deficit
- providing optimum levels of fertilizer.

The resulting transplants

- establish quickly in the field
- are hardened sufficiently to withstand the cool, windy weather and resultant sandblasting in the spring.

These techniques have enhanced the quality of Canadian transplants and resulted in increased exports of our transplants.

Optimal weed control The critical period for weed control in no-till systems is

- 16–36 days after emergence (6–11 leaf stage) for corn grown on clay loam soil
- 15–40 days after emergence (6–13 leaf stage) for corn grown on sand soil
- 16–44 days after emergence for soybean grown on sand soil.

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Mandate

The lead site of the Cereal Research Centre (CRC) at Winnipeg develops superior wheat and oat cultivars for the Canadian prairies. The centre supports cereal-breeding programs at research centres across western Canada with research in

- biotechnology
- plant pathology
- cereal chemistry
- cereal genetics
- quality evaluation.

At Winnipeg, researchers

- develop improved methods to maintain the quality and safety of stored grain and grain products
- provide screening for regional disease resistance and quality programs for the prairies.

At Morden, researchers

- develop improved cultivars and better production and protection practices for flax and field peas in the prairie region
- develop landscape plants for the prairies.

Resources

The facilities of the Cereal Research Centre's lead site are situated on the Fort Garry campus of the University of Manitoba in Winnipeg and include

- research laboratories
- greenhouse facilities
- controlled-environment plant-growth facilities
- offices for scientists and administration.

At Winnipeg, field research is carried out at a 103-ha field site at Glenlea, 12 km south of Winnipeg. The Glenlea field station operates only during the summer, but grain storage bins located there are used throughout the year for research on pests of stored grain.

At Morden, the land base covers 254 ha. The office and laboratory building at Morden includes

- research laboratories
- cold storage
- an improved phytotron
- greenhouse facilities
- a pathology-containment laboratory.

In 1997–1998, when the achievements presented in this report were completed, the centre spent $10.1 million through their operating budget, $3.8 million from the Matching Investment Initiative, $4 thousand from other special programs, and $469 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services. Local agricultural inspectors from the Canadian Food Inspection Agency and regional offices for the Prairie Farm Rehabilitation Administration are located in the new building at Morden.

Achievements

- *Staff awards and honors*
- *Hard white spring wheat breeding*
- *Increased protein in CWES wheats*
- *Genetic transformation to increase durum wheat strength*
- *Wild wheat as a protein source*
- *Orange blossom wheat midge*
- *Cereal Gene Resources Program*
- *New oat variety released this year*
- *Cereal Genome Initiative*
- *Objectives of the cereal diseases program*
- *Molecular markers for stem rust resistance genes*
- *Fusarium head blight resistance*
- *Septoria tritici blotch of wheat resistance*
- *Germplasm tolerant to wheat streak mosaic virus*
- *New method for disease assessment*
- *Quality screening of cereal samples*
- *Small-scale benchtop noodle machine*
- *Stable breeding criteria for starch properties of wheat*
- *Method for early screening of durum wheat lines*
- *Simple wheat flour swelling test*
- *CO_2 as a grain fumigant*
- *Increased efficacy of diatomaceous earth*
- *Management for field bean diseases*
- *Myriad uses for flax*
- *Powdery mildew resistance gene in pea*
- *Tips for bean, pea, and flax producers*
- *Biological control agent for foliar diseases of peas*

Staff awards and honors Dr. J. Menzies received the *Gordon J. Green Award* from the Canadian Phytopathological Society, recognizing him as Canada's outstanding young plant pathology research scientist.

Dr. P. Fields received an achievement award at the Federal Partners in Technology Workshop, held in

June 1998. The award recognizes Dr. Fields's collaborative work in the development and improvement of diatomaceous earth.

Dr. D. Harder was presented with an award of merit by the American Oat Workers. The award recognizes his development of oat stem rust resistant genes and his support of breeding programs to deliver rust resistance in oats.

Hard white spring wheat breeding To meet consumer demand and improve Canada's competitiveness in the international marketplace, a focus of the bread wheat breeding program at the Cereal Research Centre has been on the development of white-seeded hard spring wheats. Australia, whose wheat industry is based on white wheat varieties, is considered to produce the world's highest-quality wheat. Based on quality, Canadian hard white wheat varieties will compete favorably with Australian wheats. The main advantage to end users of a switch from red to white is the potential improvement in milling percentage, possibly by as much as 4%. This improvement is expected to provide a premium price for Canadian producers and a processing advantage to Canadian millers and bakers.

White wheat varieties are generally more susceptible to sprouting and perhaps other weathering components than the established red varieties. Thus, the emphasis of the breeding program has been to convert some of the most sprout-resistant red lines into a white wheat. Molecular markers and doubled haploid techniques have accelerated this transfer. As a result of this work

- two of the selected doubled haploid lines were entered in the Central Bread Wheat Cooperative Test in 1998
- the number of lines evaluated in the wheat breeding program has grown, assisted by additional funding from the producer check-off
- a significant amount of grain is now available for market testing and further quality evaluation.

Registration is anticipated by 2001.

Increased protein in CWES wheats The CWES class of wheats is distinguished by its superior gluten strength. Extra strong flours are useful to domestic and foreign millers as a blending flour that

- increases the strength of "weaker" gluten flours
- extends the shelf life of frozen dough products.

Canadian wheat producers receive a premium based in part on grain protein content. CWES varieties with superior grain protein should give a greater return to the producer. Cereal Research Centre research in CWES wheats has focused on the development of high-protein Glenlea quality wheat. Some funding for this project has been provided by Faurschou Farms Ltd., and the Matching Investment Initiative.

A marker-assisted selection program was initiated in 1994. Parental lines that contained the high-protein marker were used to make high-protein double haploid lines. More than 200 double haploid lines have been produced, and about 100 lines were yield tested in 1998. This is the first reported integration of double haploid production and marker-assisted selection in Canada. CWES double haploid lines with the high-protein gene should enter the CWES Coop Test by 2000, two to three years sooner than with a conventional breeding program.

Genetic transformation to increase durum wheat strength Transgenics have been used to transform current durum lines to obtain lines with additional protein strength. These stronger durum wheats will make Canadian wheat competitive with the high-quality "desert durums" from the southwest United States.

Wild wheat as a protein source Recent developments in wheat marketing have placed a stronger emphasis on the protein content of CWRS wheats. Tetraploid wheat, such as *T. dicoccoides,* can be used as a vector to introduce higher protein content into CWRS wheats. Accessions of *T. dicoccoides* collected from the Middle East and stored in the Cereal Research Centre germplasm collection have been evaluated for

- restricted fragment length polymorphism
- protein content
- seed mass.

Six accessions that combined high protein content with superior seed mass were chosen as high protein donors in a crossing program with CWRS and CWES. Wheat lines containing 0.8–1.1% unit higher levels of protein are now well advanced in both programs. The higher protein levels have been shown to have the same contributions to bread and pasta quality as protein in wheat without the *T. dicoccoides* genes. Partial funding for this project is provided by the Western Grains Research Foundation and the Matching Investment Initiative.

Orange blossom wheat midge Wheat midge is the most important insect pest of wheat in Manitoba and Saskatchewan. Entomologists and breeders work together on breeding for midge resistance in wheat. Their findings include:

- the main type of resistance operating against the midge is antibiosis
- antibiosis suppresses the development of newly-hatched larva and eventually kills them before they can damage the wheat seeds
- some lines suppress egg laying and others suppress egg hatching.

Using both traditional crossing and double haploid methods, wheat midge resistance has been incorporated into many CWRS, CPS, and CWES lines that are currently advancing through the wheat breeding program. Two CPS lines have been developed that

- exhibit very high levels of midge resistance
- are high-yielding
- perform well agronomically.

These lines were entered in the High Yield Wheat Coop Trial in 1998 and may be candidates for registration by 2001.

Cereal Gene Resources Program The Cereal Gene Resources node at the Cereal Research Centre (CRC) operates in collaboration with Plant Gene Resources of Canada (PGRC), Saskatoon, and the University of Manitoba, Winnipeg. The focus of this work is to rejuvenate, characterize, and evaluate accessions of the Canadian National Germplasm Collection. Research scientists at the Cereal Research Centre are currently evaluating

- wheat, oat, and barley accessions for insect and fungal resistance
- novel wheat quality characteristics.

About 43 000 accessions of the three species are in storage at the PGRC.

New oat variety released this year The objective of the Prairie Oat Breeding Consortium is to contribute to the stability and international competitiveness of oat production in Canada by developing and releasing oat varieties adapted to the Canadian prairies, specifically those areas affected by rust. These new varieties are superior to currently recommended varieties in one or more of the following criteria:

- yield
- disease resistance
- kernel quality
- agronomic characteristics.

The variety AC Rebel (OT277) was released this year. AC Rebel has a higher protein content and is well suited to the western prairies, but it lacks adequate crown rust resistance for the eastern prairies.

Cereal Genome Initiative As part of a larger world-wide genomic initiative, work is under way to identify the entire wheat genome (i.e., all DNA gene sequences and their related expressions in wheat). The focus at the Cereal Research Centre is to identify genes for

- disease resistance
- stress tolerance
- quality
- general agronomic traits.

Objectives of the cereal diseases program In general, all activities within the plant pathology section of the CRC ultimately relate to incorporating effective resistance into adapted cultivars. Surveys are conducted annually in Canada for the early detection of possible new disease virulence in

- wheat
- barley
- oat.

Incidence and virulence is monitored for

- leaf rust (cereals)
- stem rust (cereals)
- smut (cereals)
- crown rust (oats).

Greenhouse and field test lines of cooperative, breeder's, and international nurseries are also evaluated annually for resistance or tolerance to different pathogens and insect pests. The results of these evaluations are used to provide decisions on continuance of lines in breeding programs, as well as future registration of the lines as cultivars.

Molecular markers for stem rust resistance genes Researchers have identified DNA markers for genes SR39 and SR40. These markers have been sequenced and converted to sequence-amplified repeat units, resulting in effective and reliable markers for these genes.

Fusarium head blight resistance Fusarium head blight (FHB) was once again prevalent in wheat and barley in Manitoba and was found in all fields surveyed in 1998. Estimated losses, based on preliminary calculations, average

- 10% in wheat
- 6% in barley (yield alone).

Resistance to FHB has been found in a poor-quality wheat variety from China. It has been transferred to Canada Western Red Spring and Canada Prairie Spring wheats as part of the ongoing wheat-breeding program. A FHB-resistant CPS wheat line with good yield and quality is expected to receive registration in 2001. Resistant varieties of hard red spring and CWES are under test as well, with registration expected in 2002.

Septoria tritici blotch of wheat resistance The severity of *Septoria tritici* blotch of wheat has increased during the past 10 years and has prompted development of wheat cultivars resistant to the disease. An understanding of the inheritance of resistance can hasten the transfer of resistance to desirable germplasm. In a study of five crosses of spring wheat, resistance was identified in a Brazilian wheat line *6 Lacos-78*. This line is currently in use as a source of resistance in the breeding program. Screening of other sources of resistance is ongoing.

Germplasm tolerant to wheat streak mosaic virus Wheat streak mosaic virus (WSMV) is an important viral disease of wheat in western Canada. CRC researchers have identified advanced germplasm with high tolerance to the virus. Lines containing this germplasm are now in the early stages of the breeding program. Recently, a WSMV resistance gene from Kansas winter wheat was introgressed into current CWRS lines.

New method for disease assessment CRC researchers have developed new quantitative indoor assays for assessing the effects of

- barley yellow dwarf virus on wheat and oat
- wheat streak mosaic virus on wheat.

The assay is a useful tool as testing indoors allows three or four rounds of selection per year, compared with only one assessment per year in field tests.

Quality screening of cereal samples The CRC's quality laboratory analyzed more than 29 000 samples of wheat, barley, and oats in 1998 for quality at both the early and advanced stages of cultivar development. Up to 20 individuals were employed throughout the season, with double shifting of some equipment for such tests as

- milling
- farinograph
- mixograph
- falling number
- protein.

A $0.5-million investment in new equipment has facilitated this testing.

Small-scale benchtop noodle machine The prototype for a bench top laboratory noodle sheeter was fabricated at the centre and subsequently modified by a tool and die company. Using just 10 g of flour, the apparatus produces noodle quality evaluation results that are similar to commercial pilot plant production lines. The bench top machine is now used routinely to evaluate advanced breeders lines in the centre's wheat breeding program.

Stable breeding criteria for starch properties of wheat Starch is a major component of cereal grains. It is desirable to produce a range of cultivars with starches of differing properties, because

- starch has varied food and industrial uses, requiring starches with distinct physical and chemical characteristics
- variation in starch composition among cultivars affects the quality of wheat end-use products, such as noodles, pasta, and bread.

CRC researchers studied the effects of genotype, environment, and the interaction of the two on the starch properties of a range of spring wheat cultivars. Results indicated that genotype highly influences, and environment and the interaction of genotype and environment only slightly influence

- flour swelling volume
- starch breakdown
- starch content.

This information gives breeders confidence that these starch characteristics are environmentally stable and can be reliably measured as part of a screening program.

Another study looked at the variation of starch granule size in durum wheat cultivars. Manipulation of this characteristic through plant breeding may have an impact on surface texture properties in pasta.

Method for early screening of durum wheat lines CRC reseachers have developed electrophoretic techniques to screen early durum lines for gluten strength (on the basis of B-LMW subunit patterns). With this new method, about 120 single kernel samples can be assessed in a day. In contrast, the gluten index method uses more than 10 g of seed and in most cases requires milling time. Used in combination with the gluten index and protein content testing, the goal of developing higher protein (stronger) durum cultivars can be achieved more quickly.

Simple wheat flour swelling test Flour swelling tests are used to assess differences in starch properties between cultivars. CRC researchers have developed a modified test that uses about 30 mg of flour. Advantages of this test over standard procedures (the Brabender Viscograph and the RapidVisco Analyzer) are that it

- avoids the use of a high-temperature water bath
- does not require a set of uniform and leak-proof tubes that have to be carefully cleaned after each use.

The new method is rapid, easy, and inexpensive and can be used to evaluate large numbers of wheat lines for starch properties in early generations.

CO_2 as a grain fumigant The fumigation of stored grain with carbon dioxide is a commercially viable option for insect control. To use the technology, producers must

- ensure that bins are airtight
- install a pressure relief valve and re-circulation pump at a cost of about $320.

Dry ice treatment over a period of 7–10 days when grain temperature exceeds 20°C controls insects such as the rusty grain beetle at a cost comparable to phosphine fumigation.

Increased efficacy of diatomaceous earth In 1993, CRC and Hedley Technologies Inc. began a collaborative research project to develop a new, nonchemical insecticide to replace chemicals, particularly methyl bromide, (an ozone depleter) that are used to protect postharvest grain. Their development of an improved diatomaceous earth (DE), now marketed by Hedley under the trade name Protect-It^{TM}, was recently recognized with a *Federal Partners in Technology Transfer Award.* This collaboration between government and private industry has opened up new markets, both nationally and internationally for the company. Field trials on the use of heat and DE in combination were conducted at the Quaker Oats mill and processing facility in Peterborough, Ont. Results showed that a heat–DE combination was more effective than heat alone.

Management for field bean diseases The most important field bean diseases in Manitoba are white mold *Sclerotinia* and bacterial blights (common bacterial blight and halo blight). These diseases occur annually in Manitoba and can reduce yields up to 50%. Researchers at Morden recommend the following disease control methods for field bean producers:

- choose a resistant/tolerant variety
- use disease-free seed
- use treated seed
- apply fungicide
- rotate crop with cereals and corn
- widen row spacing, or reduce seeding rate
- avoid excessive use of nitrogenous fertilizer
- avoid working on infested fields.

Myriad uses for flax Morden is the only research centre with a breeding program in flax. The recently released Morden variety AC Emerson was grown on almost 20% of the flax acreage in Manitoba in 1998 because of its

- resistance to chlorosis
- high yield.

The breeding program focuses on developing linseed lines with improved linolenic acid content and quality for industrial use. A flax line with 73% of its oil as linolenic acid, compared with a normal 58%, was developed in cooperation with NorCan Seeds and the Matching Investment Initiative. It is being produced under Identity Preserved production. Work is also under way to develop linola varieties that can be used as edible oil. Besides industrial oils, linseed has a number of uses:

- processing flax straw into paper products
- using flax fibers in moldings on luxury cars
- blending flax fibers with pulp to produce compressed boards.

Powdery mildew resistance gene in pea Pea is an important grain legume that can suffer significant loss of yield (25–30%) and quality from powdery mildew infection. Morden researchers looked to other countries to identify pea varieties that appear to resist infection, with the aim of incorporating this resistance into varieties in western Canada. Accessions from 335 pea varieties from 34 countries were evaluated for reaction to powdery mildew in naturally infested fields at Morden. As a result of this evaluation

- eight genotypes were found to show resistance and five, moderate resistance
- these genotypes are now used in the Morden breeding program
- a powdery mildew resistant yellow pea was registered in 1998
- resistant yellow and green peas will be released in 1999.

Incorporation of mildew resistance into commercially adapted cultivars will stabilize yield and reduce production costs.

Tips for bean, pea, and flax producers CRC researchers have found that soil moisture conditions improve with certain management practices for various crops:

- spacing rows closer than the traditional 30 inches when planting dry beans (this practice increases yield by about 10% because of reduced loss of moisture between rows)
- using zero till for bean, pea, and flax.

Biological control agent for foliar diseases of peas CRC researchers have filed a provisional U.S. patent ("*Gliocladium* strains useful in the control of fungal pathogens") on a potential biological control agent. This agent has been shown to be effective as a seed treatment in protecting peas and other crops from fungal diseases. A series of comparative growth studies were carried out at Morden to test the efficacy of the agent (designated ACM941) for soil-borne diseases of peas. Large-scale testing in collaboration with industry is underway to determine

- optimum storage conditions
- length of time it remains effective
- the range of pathogens controlled by the organism.

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Mandate

The Brandon Research Centre is a national centre of expertise for land resource management in western Canada. A multi-disciplinary team of scientists has been assembled to develop sustainable crop and livestock production systems for the Parkland, a vast agro-ecological region of the Canadian prairies. This research team advances scientific knowledge and delivers innovative technologies in the areas of

- agricultural management systems and land resource conservation for the Black and Dark Gray soil zones
- soil and land resource database management and evaluation
- agro-ecological processes and environmental sustainability
- varietal development of barley
- beef and pasture management
- manure management.

Resources

The Brandon Research Centre is one of the five original experimental farms established by the federal government through an act of Parliament in 1886. The Land Resource Unit, located in Winnipeg, is an integral component of the Brandon Research Centre. The centre's land base covers 838.1 ha of owned land and 477 ha of leased land.

In 1997–1998, when the achievements presented in this report were completed, the centre spent $5.3 million through their operating budget, $2.7 million from the Matching Investment Initiative, $31 thousand from other special programs, and $156 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

The 7295-m^2 office and laboratory building includes

- modern research laboratories
- computer-controlled environment chambers and greenhouses
- long-term cold-storage units
- a library and information centre
- conference rooms
- offices.

Local staff from the Prairie Farm Rehabilitation Administration and Canadian Food Inspection Agency are also located in the building.

Achievements

- ***Staff awards and honors***
- ***Methane production by beef cows***
- ***Pasture finishing of beef***
- ***Beef cattle management in Manitoba***
- ***Development of stem rust nursery***
- ***New barley varieties***
- ***New scald resistance gene in barley***
- ***Management of legume-derived nitrogen***
- ***New decision support tool for grain and oilseed production***
- ***Feeding strategies to improve swine manure management***
- ***Assessment of soil quality***
- ***Mapping of selected trace elements***

- ***Sulfur management in canola***
- ***Fertility management in solin***
- ***Reduced seedling damage from urea fertilizers***

Staff awards and honors Dr. Doug Derksen was named *Canadian Zero-Till Non-Farmer of the Year* by the Manitoba–North Dakota Zero Tillage Farmers Association. The honor recognizes his research and development of integrated pest management for conservation tillage systems. This recognition by producers attests to his continuing success in transferring results of research into new principles and practices for farm management today.

Dr. Cynthia Grant was the 1997–98 recipient of the *Robert E. Wagner Award (Young Scientist Category)* presented by the Potash & Phosphate Institute. The award recognizes distinguished contributions to advanced crop yields through research on maximum yield and management of maximum economic yield. Her research and extension activities focus on fertilizer management under different tillage systems in the Canadian prairies. Her work on improving the efficiency of fertilizer use has led to new management practices for cereals, oilseeds, and alfalfa.

Dr. Loraine Bailey was named one of the *1998 American Society of Agronomy Fellows* for his professional achievements and meritorious service in the advancement of agriculture on the Canadian prairies. The honor recognizes his contributions to the development of environmentally sustainable management practices, which have increased production efficiency while being protective of Canada's soil resource.

Methane production by beef cows Domestic animals, primarily cattle, may produce as much as 15% of the world's output of methane and therefore be considered significant contributors to the greenhouse effect. Most studies have measured methane production from dairy cattle confined in respiration chambers. There is little information on beef cattle under range or pasture conditions.

To address this need, scientists used sulfur hexafluoride in a tracer-gas technique to measure methane production from lactating beef cows grazing alfalfa–grass pastures and grass-only pastures. Cows grazing alfalfa–grass pastures
- consumed more dry matter (11.4 versus 9.7 kg a day)
- produced less methane (373.8 versus 411.0 L a day)
- lost less energy through methane release (7.1 versus 9.5% of gross energy intake)

than cows grazing grass-only pastures.

The findings confirm that pasture type has an effect on methane production and feed efficiency. Producers can use the new information to improve grazing management. Changing diet composition is a practical and economical way can make beef cows more environmentally friendly.

Pasture finishing of beef Because of the high costs associated with feedlot finishing, there has been greater producer interest in using as much pasture as possible to produce beef. Results from grazing trials suggest that it is possible to finish cattle directly off pasture to meet Canadian A-grade standards.

Researchers determined the quality of meat from steers and heifers finished on alfalfa–grass pastures alone or supplemented with steam-rolled barley. In comparison to steers, heifers
- gained less weight
- had lighter carcasses, smaller rib-eye areas, lighter-colored rib eyes, and thicker grade fat
- were more tender
- yielded lower gross returns per head
- were more likely to be graded A or better.

Feeding supplemental grain on pasture increased pasture gain and hot carcass weight but did not improve
- carcass grade and value
- chemical, sensory (taste panel), and shear-test (tenderness) ratings
- gross return per head.

These findings suggest that heifers may be more desirable for pasture finishing unless early-maturing steers with good marbling genetics are available. Grain supplementation on pasture could still be profitable for producers. When stocking rates are high and pasture growth is inadequate to meet animal needs, substituting grain for grass would allow for efficient use of pastures, without overgrazing.

Beef cattle management in Manitoba Currently, 11% of Canada's beef cow herd is in Manitoba. The province is poised for rapid expansion of its cattle industry because of availability of land for hay or pasture and removal of grain transportation subsidies. A survey of beef operations was conducted to

- provide baseline information for measuring change in the industry
- identify producer concerns
- prioritize research needs.

A total of 507 surveys were completed, representing 4% of farms with beef cattle and 5% of cow/calf operations reported for Manitoba in the *1996 Census of Agriculture*. The surveys were used to characterize

- farm operation
- overwinter animal management
- forage and pasture management
- reproductive management
- factors limiting profitability.

The typical beef cattle farm is a commercial herd of fewer than 50 exotic-type cattle that contribute less than 50% of both total income and farm income. The typical wintering period averages 220 days, starting in late October. Most cows are overwintered in a drylot with a shed for shelter and are given hay and straw, supplemented with barley and minerals. The typical grazing period on native and unimproved pastures averages 145 days, starting in late May. Producers take two cuts of alfalfa–grass hay and thresh cereals, such as barley. The calving season typically begins in January and February (for 60% of beef farms) but does not end until May and June. Bulls are left with heifers and cows for more than 90 days during the breeding season. Respondents ranked cost of production, pasture availability and quality, and reproduction as the top three factors limiting profitability of their beef operations.

Development of stem rust nursery The Brandon Research Centre has developed a barley stem rust nursery with funding from the Western Grains Research Foundation that started in 1992. For the past 50 years, scientists have depended on one gene (*Rpg 1*) in barley to confer stem rust resistance. The difficulty is that stem rust is highly variable and is constantly evolving new races, such as QCC, that could potentially be devastating to barley grown in western Canada.

During this project, researchers identified and incorporated several sources of moderate resistance, including PC 11 and Q21861 from CIMMYT in Mexico. It will be a few years before barley breeders can register a QCC-resistant variety. In the meantime, the disease nursery will help Agriculture and Agri-Food Canada scientists respond more effectively, should another epidemic strike the prairies.

New barley varieties The line HB105 was approved for registration and will be marketed as AC Bacon by SeCan Association. This six-row hulless barley has

- wide adaptation to both eastern and western Canada
- high yield and strong straw
- kernel quality equal to Falcon, but no problems with neck breakage or shelling out.

These features make AC Bacon ideal for swine rations and attractive to producers targeting the expanding swine feed market in western Canada. AC Bacon will be available for commercial production in 2000.

After successful plant-scale testing, the malting and brewing industry approved AC Metcalfe. This variety is the first two-row malting barley to be released by the Brandon Research Centre. SeCan Association has the distribution and marketing rights for seed of AC Metcalfe. It underwent pedigreed seed increase in 1998 and will be available for commercial production in 1999.

AC Metcalfe has the potential to replace Harrington as the dominant malting variety grown in western Canada, occupying 25% of all barley acreage. The most outstanding features of AC Metcalfe are its agronomic performance and malting quality, including

- three days earlier maturity than Manley
- 7% higher yield than Harrington
- higher test weight and kernel plumpness than Manley
- moderate to good resistance to the smuts, net blotch, and fusarium head blight
- better malting quality traits than Manley and Harrington, particularly malt extract.

New scald resistance gene in barley Leaf scald (*Rhynchosporium secalis*) of barley is one of the most serious barley diseases in western Canada. Yield losses average 10% in Alberta but have been as high as 30%. Quality losses can be more significant when the disease inhibits kernel filling and prevents marketing grain as malting quality. None of the malting barley varieties now registered for western Canada is resistant to scald. A new source of resistance to a highly virulent form of scald (WRS1860 isolate) was identified in the Turkish barley accession MEH151-1. This resistance is

- the result of a gene or cluster of genes linked to the Falc666 specific amplicon on chromosome 3
- not part of the *Rh* gene cluster, the most commonly used source of resistance, which is breaking down under the new forms of scald.

Barley breeders are using marker-assisted selection to incorporate the new scald resistance gene into new barley varieties. The most important benefits of this breeding method are

- greater precision of selection
- ability to select in the absence of the pathogen
- less labor and resources needed when screening with molecular markers.

Management of legume-derived nitrogen Producers typically terminate established stands of alfalfa by intensive tillage. Recently, however, herbicide application has been proposed as an alternative, given the potential to reduce soil erosion and soil moisture loss. Results from a series of controlled-environment studies show that termination by herbicide rather than tillage reduces the short-term supply of plant-available nitrogen because of

- reduced mineralization of surface residues
- increased volatile losses of nitrogen from surface residues.

Termination method influences both the amount and timing of nitrogen released from decomposing alfalfa stands. This information may provide producers with a management strategy for reducing potential nitrogen losses from cropping systems while improving the efficiency with which legume-derived nitrogen is used by subsequent crops.

New decision support tool for grain and oilseed production Loss of crop residue resulting from decomposition and fragmentation is an important factor in soil organic carbon and soil quality. A joint effort by the Brandon and Saskatoon Research Centres has led to a new model of residue decomposition and its incorporation into the *Sustainable Farming Systems Model* recently developed by the Centre for Studies in Agriculture, Law and Environment at the University of Saskatchewan's College of Agriculture. Agriculture and Agri-Food Canada scientists evaluated a model of residue decomposition originated by the U.S. Agricultural Research Service for spring and winter wheat. Work at the Melfort Research Farm extended the American model to oilseed and pulse crops.

The *Sustainable Farming Systems Model* will be used by client groups and planners as a policy analysis tool to assess the environmental and economic sustainability of specific grain and oilseed production systems at the ecodistrict level in Saskatchewan.

Feeding strategies to improve swine manure management Results from studies with grower–finisher pigs to find ways of reducing nutrient losses and odor emissions from manure show that

- feeding hulless barley increases the digestibility of dietary energy and reduces the output of manure on a dry matter basis by about 33% when compared to feeding hulled barley
- using amino acid supplements (lysine, threonine, methionine, and tryptophan) in place of protein supplements with hulless barley diets reduces the amount of nitrogen excreted in swine manure by about 28%, compared to feeding standard hulless barley and soybean diets
- adding phytase, a digestive enzyme, reduces the amount of phosphorus excreted in swine manure by about 35% for hulled barley diets and 45% for hulless barley diets
- adding a Yucca plant-based extract to both feed and manure tends to reduce the intensity of manure odors from pigs on hulled barley diets.

Producers can use the new information to formulate diets that minimize the impact of swine manure on the environment. This step will help to alleviate public concerns over air and water quality with the rapid expansion of swine production in western Canada.

Assessment of soil quality Researchers have developed a new model and set of procedures to assess soil quality at national and regional scales. Based on geographic information system (GIS) technology, the model

- uses existing digital land resource databases for the major agricultural regions of Canada
- allows for fully reproducible results
- facilitates comparison of the assessments at different time intervals and with updated land resource information.

The new model can be used by other researchers, provincial and federal government agencies, and the private sector

- to measure soil quality for crop production and sustainable development
- to classify soil quality and stability under changing conditions, when integrated with other models, such as the *Universal Soil Loss Equation* or *Century Model*
- to assess soil quality under different land use and management scenarios on a local-site scale (although it was developed on a broad scale).

Mapping of selected trace elements The Manitoba map of the *Soil Landscapes of Canada* was used to portray the distribution and concentration of 13 metals, one semimetal, and one nonmetal that commonly occur in the environment in trace amounts. More than 1000 soil samples were collected from 121 cultivated landscapes in southern Manitoba. The new information on background levels of these trace elements is being used by

- environmental agencies, to assess the severity of soil contamination and design site remediation standards
- planners, to manage the application of animal waste and sewage sludge and effluent in an environmentally responsible way
- agriculturalists, to determine deficiencies for plant growth and potential toxicities in animal browse and feedstuffs
- researchers, to investigate how grain and oilseed quality is affected by fertilization of crops grown in areas with known high levels of trace elements, such as cadmium.

Sulfur management in canola Sulfur deficiencies are occurring more often in western Canada because of increased

- crop yield
- adoption of reduced tillage systems and continuous cropping
- production of crops, such as canola, that remove large quantities of sulfur from the soil.

Several sources of sulfur on the market differ in their availability to the crop and reactions within the soil. Field studies confirm that elemental sulfur and Tiger 90 are not effective sources of sulfur for canola in the year of application. Producers are encouraged to use a sulfate source of sulfur, such as ammonium sulfate or ammonium thiosulfate, if a soil deficiency exists and a crop response is required in the current growing season. Suitable methods for applying all sulfate sources are

- broadcasting
- banding
- seed placement.

Because of its slow release, the elemental sulfur form may be an effective residual source of sulfur for several years after application, indicating a role in long-term management of rotational or perennial crops. The new information is expected to aid producers in selecting an efficient and cost-effective method of sulfur management for their farming operations.

Fertility management in solin Solin is a category of flax, recently developed, with oil characteristics similar to those of sunflower. Stability and long shelf life have made solin oil sought-after in the edible oil market. Research on the fertility needs of solin was needed because

- solin differs from traditional flax varieties in its oil characteristics and thus may have different nutritional requirements
- much of the information on fertilizer management in flax was generated before yield potential increased with improvements in weed control and other agronomic practices.

Field studies confirm that solin responds to nitrogen and phosphorus application under varying soil and environmental conditions in much the same way as traditional flax varieties. Therefore, producers can safely apply fertilizer recommendations for traditional flax varieties to the new solin varieties.

Reduced seedling damage from urea fertilizers Seed placement of fertilizer is a popular option for producers, as it allows seeding and fertilizer application in a single operation. However, when urea-based fertilizers are seed-placed at rates needed to optimize crop yield, there is often severe seedling damage, as indicated by a reduction in

- stand density
- emergence rate
- seedling vigor.

In barley, seedling damage can occur when applying nitrogen at rates as low as 40 kg/ha. Fertilizer banding or incorporation can lessen the damage, but these practices are undesirable for reduced tillage.

Under a Matching Investment Initiative project with fertilizer industry partners and the Western Grains Research Foundation, Agriculture and Agri-Food Canada scientists have determined that use of a urease inhibitor is effective at

- reducing the risk of seedling damage in barley by lowering the concentration of ammonia in contact with the germinating seedlings
- increasing the amount of urea nitrogen that can be safely placed with the seed in a one-pass seeding and fertilizing system.

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Sustainable Land Management

Manager, Melfort Research Farm; Superintendent, Scott Research Farm; Weed management K.J. Kirkland, M.Sc.
Agronomy S.A. Brandt, M.Sc.
Cropping systems A. Johnston, Ph.D.
Extension, weed management E. Johnson, B.S.A. (seconded in from Sask. Agric. & Food, on educational leave)
Pathology H.R. Kutcher, Ph.D.

Forage seed production H.A. Loeppky, M.Sc.
Soil conservation & management S.S. Malhi, Ph.D.
New crop evaluation C. Vera, M.Sc.

Mandate

The Saskatoon Research Centre and its research farms bring a long-term commitment in crops research to the agri-food industry in western Canada. The centre delivers

- improved germplasm of oilseed and forage crops
- crop-production and pest-control practices for the Parkland region
- research to expand the utilization of prairie crops
- conservation, documentation, and distribution of diverse germplasm by Plant Gene Resources of Canada.

Biotechnology and chemistry strongly support each program.

Resources

The main office–laboratory building, including the greenhouse–growth chamber complex, is located on the University of Saskatchewan campus in Saskatoon, Sask. Saskatoon is recognized as a major world centre for research and development in agricultural biotechnology. This location encourages collaboration with other research establishments, both public and private. Offices, laboratories, and shops support the programs at Scott and Melfort. In 1997–1998, when the achievements presented in this report were completed, the centre spent $14 million through their operating budget, $3.2 million from the Matching Investment Initiative, $1.7 million from other special programs, and $769 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

Construction of the south wing of the Saskatoon Research Centre, which includes the greenhouse–headerhouse complex, several laboratories, and Plant Gene Resources of Canada, is now complete. Plant Gene Resources of Canada transferred seed from Ottawa to its new facilities in April, 1998. A new field services building nears completion at the Saskatoon farm site. The facilities will house laboratories for seeding preparation, data processing, and oilseed analysis. It will facilitate efficient post-harvest processing of field samples.

The centre has a 242-ha field site 5 km northeast of the university. The Scott Research Farm has a land base of 349 ha located 160 km west of Saskatoon. Staff of this research farm also manage field sites at Lashburn and Loon Lake. Melfort Research Farm is located on 371 ha of land near Melfort, 200 km northeast of Saskatoon.

Achievements

- ***Staff awards and honors***
- ***Completion of renovations and expansion of the Saskatoon Research Centre***
- ***New equipment for crop utilization group***
- ***Move of Plant Gene Resources of Canada to Saskatoon***
- ***Formation of molecular genetics research team***
- ***Expanded Commercialization Unit***
- ***New canola additive for diesel fuel***
- ***New canola cultivars***
- ***Better strategy for herbicide application***
- ***Reduced herbicide use through better fertilizer application***
- ***New way to estimate chalcid damage***
- ***Increase forage productivity with proper phosphorus placement***
- ***Monitoring herbicide-resistant weeds***
- ***Brochures available to seed growers***
- ***Library holding of Green Plan final reports***
- ***New type of canola***
- ***Improved fall seeding with coated canola seed***

In Memoriam: Dr. Robert Patrick (Bob) Knowles 1919–1997 Dr. Bob Knowles began his long and distinguished career with Agriculture and Agri-Food Canada as a summer student in 1938. He became a full-time staff member of the Dominion Forage Crops Laboratory in 1948 and served in this capacity until his retirement in 1985.

Dr. Knowles was the principal scientist, credited with breeding

- Carlton, Magna, Signal, and Radisson smooth bromegrasses
- Fleet and Paddock meadow bromegrasses
- Summit, Parkway, and Kirk crested wheatgrasses
- Chief intermediate wheatgrass.

Dr. Knowles headed up the Crops Section from 1964 to 1971 and the Plant Breeding Section from 1971 to 1976. He continued his work as an emeritus scientist until his death on December 29, 1997. He published more than 140 scientific and technical papers.

During his career, Dr. Knowles received several significant honors, including Agriculture and Agri-Food Canada's first lifetime designation of Emeritus Research Scientist in 1990. A statement taken from the presentation of his honorary Doctor of Laws degree in 1987 aptly describes Dr. Knowles as "quietly and effectively establishing himself nationally and internationally as the Dean of Canadian grass breeders, a man who is respected by his colleagues and by the farmers he serves."

Staff awards and honors The Saskatchewan Institute of Agrologists Wall of Honor at the University of Saskatchewan recognizes significant contributions made to the progress and welfare of agriculture and the food industry in the province of Saskatchewan. Several of the 164 people named on the plaque are current or former employees of Saskatoon Research Centre. These include

- M. Cormack (1960)
- J. Bolton (1961)
- W. White (1963, 1974)
- R. Greenshields (1967, 1979)
- H. Fredeen (1967)
- R. Knowles (1971)
- K. Downey (1976)
- L. Putnam (1978)
- B. Goplen (1989)
- K. Kirkland (1992).

Dr. Keith Downey, emeritus scientist, was recognized by the Province of Saskatchewan for his pioneering efforts and spirit in the transformation of rape into today's multi-million-dollar canola industry. Downey Road in Innovation Place, a research park specializing in agricultural biotechnology, is named after Dr. Downey.

Two research teams based at the Saskatoon Research Centre received Agriculture and Agri-Food Canada's Agcellence Awards in recognition of their significant achievements.

- One team received the innovation award for developing AC Grazeland Br, the world's first bloat-reduced alfalfa.
- The second team received an award for their contribution to the agri-food sector through development of integrated pest management strategies for wheat midge.

Completion of renovations and expansion of the Saskatoon Research Centre The 10 June 1998 marked the official opening of the expanded Saskatoon Research Centre by the Minister of Agriculture and Agri-food Canada, the Honorable Lyle Vanclief. Three phases of construction have been completed over the past 4 years.

Phase I involved refurbishing the original laboratory building.

Phase II, construction of the scientific support wing on the north end of the original building, was completed in the spring of 1997. It houses

- the library
- computer services
- conference and meeting rooms
- offices for scientists and administration
- lobby
- cafeteria.

The south wing, phase III of the construction, includes the greenhouse–headerhouse complex and the new home for Plant Gene Resources of Canada, Canada's national seed bank. Nine greenhouses provide more than 700 m^2 of bench space in a fully automated environment. The headerhouse contains

- laboratories for entomology, pathology, weed and forage research, and plant breeding
- a potting area
- autoclaves
- microbial fermentation and containment labs for the development and testing of biological control agents for both insects and weeds.

There are sophisticated facilities for spray-application technology and an area containing several growth chambers and incubators.

New equipment for crop utilization group The Canada–Saskatchewan Agri-Food Innovation Fund has provided $800 thousand to the centre's Crop Utilization Section to purchase five new pieces of equipment. These purchases will enhance the group's capability to seek value-added commercial technologies and partnerships with private sector companies in areas of botanical extracts and nutraceuticals. The new equipment includes: a preparative chromatographic system, a controlled stress precision rheometer, an updated console for the Bruker AM400 NMR spectrometer and a bench-top Electro-Spray HPLC Quadrapole Mass spectrometer.

Move of Plant Gene Resources of Canada to Saskatoon Agriculture and Agri-Food Canada's Plant Gene Resources of Canada (PGRC) was relocated from Ottawa to Saskatoon, moving it closer to the major plant breeding programs in western Canada for

- cereals
- oilseeds
- forages.

PGRC now joins the body of expertise in plant genetics and breeding involving a cluster of public research institutions and biotechnology companies on the University of Saskatchewan campus and in the neighboring research park, Innovation Place.

PGRC is associated with the worldwide network of plant gene banks in collaboration with the International Plant Genetic Resources Institute. Gene banks were established to conserve the genetic diversity of cultivated crops, their wild ancestors, and native plant species. Genetic diversity decreases because of large-scale production of genetically uniform crops. As genetic diversity is lost, a crop's vulnerability to pests, diseases, and abiotic growing conditions increases. Gene banks work to prevent the loss of genetic traits and act as a source of genetic material from which improved crop varieties can be developed.

PGRC stores 110 000 seed samples from Canada and around the world. It holds

- world-base collections of barley and oat
- duplicate world collections of pearl millet and oilseed–green manure crucifers
- samples of rare and threatened Canadian plants, in order to protect them from extinction.

PGRC coordinates Canada's multi-nodal germplasm system. Six nodes are responsible for rejuvenation and evaluation of specific crops, while PGRC is the main seed repository. The nodes located in centres across Canada deal with

- crucifers
- cereals
- potatoes
- pulse and special crops
- Canadian clonal gene bank
- forages.

Formation of molecular genetics research team The molecular genetics research team was brought together in Saskatoon in August 1997 to become an integral part of Agriculture and Agri-Food Canada's centre of excellence for agricultural biotechnology. The objective of this group is to use genetics to improve oilseed germplasm. Genomics will allow researchers to

- clone genes much faster
- understand exactly what particular genes do
- design new gene structures
- program new patterns of gene expression.

One obvious application will be designing new plant genes for resistance to blackleg and other diseases. This work is important for keeping pace with the potential of the disease microorganisms to evolve into new virulent forms.

Automation is a key element in many of the processes involved in marker-assisted breeding and genomics. The centre has acquired state-of-the-art equipment over the past 2 years. Robotic equipment, such as the automated colony picker, is vital for processing huge numbers of samples quickly and precisely.

Expanded Commercialization Unit The Commercialization Unit of the centre is a relatively new initiative. Commercialization officers liaise between our research staff and potential business partners to present our innovative technologies for

- patenting
- licensing
- commercial development.

New canola additive for diesel fuel Canadian winter temperatures often dip below –30°C, the temperature at which most diesel fuel will freeze. Canada makes a special diesel fuel for winter use that continues to flow at very low temperatures (–45°C). However, this winter diesel fuel is not an effective lubricant, a feature required by diesel engines. Low lubricity causes engine wear and poor fuel economy. Therefore, something is needed to enhance winter diesel fuel's lubricity.

A research partnership was formed among

- Agriculture and Agri-Food Canada's Saskatoon Research Centre
- the Department of Mechanical Engineering at the University of Saskatchewan
- Canodev, the marketing arm of the Saskatchewan Canola Development Commission.

These partners have developed a lubricity additive for diesel fuel from canola oil. When added to diesel fuel at 0.5–2%, it increases the lubricity of winter diesel fuel to the same level as that of summer diesel fuel.

This added value is good news for canola producers. Canada produces 6 million tonnes of canola annually. Each year 10% of the canola crop is severely downgraded by various factors, such as

- improper storage
- weather damage
- contamination.

Most of the downgraded Canadian canola could be used to produce the lubricant to treat Canadian diesel fuel.

The new additive is also good for diesel users. Canadian consumption of diesel fuel in 1994 was 16 billion kg. Adding 160 million kg of canola oil lubricant to this fuel could

- save 1.1 billion kg of diesel fuel
- prevent the emission of 3 billion kg of carbon dioxide into the atmosphere.

New canola cultivars Innovator, the first registered transgenic canola in Canada, was developed through a partnership of Agriculture and Agri-Food Canada and private industry. One of the unique characteristics of Innovator is that it is tolerant to the broad spectrum herbicide glufosinate ammonium.

Exceed, a new variety registered in 1998, improves on Innovator by retaining the qualities of high protein and low glucosinolates while

- producing yields that are more than 10 % higher
- containing slightly more oil.

Better strategy for herbicide application Field tests in westcentral and northwest Saskatchewan show that 2,4-D provides effective control of winter annual weeds, such as stinkweed or flixweed, prior to seeding either Argentine or Polish canola. Tests were conducted in three soil zones of the Parkland region:

- Black
- Dark Brown
- Gray Wooded.

Prior to this research, it was not known whether residual 2,4-D in the soil would cause damage to the succeeding canola crop.

Applying 2,4-D in October could benefit producers who

- use zero-tillage
- use direct-seeding
- practice conventional tillage and wish to avoid a late fall tillage.

Reduced herbicide use through better fertilizer application Subsurface banding of nitrogen is preferable to broadcast application because it reduces wild oat and broadleaf weed emergence in spring wheat. A 3-year study over three ecoregions of the Great Plains indicates that using banded fertilizer application is a valuable component of integrated weed management.

Compared with broadcasting fertilizer, side banding of nitrogen resulted in

- 22% fewer wild oat plants
- 10% less biomass of wild oat
- 18% less nitrogen uptake by wild oat plants.

Side banding of nitrogen may provide effective weed management with reduced herbicide use when combined with other cultural strategies, such as choosing

- appropriate crop-seeding rates
- competitive crops.

Reducing herbicide use lowers pesticide load in the environment and slows the development of herbicide-resistant weeds.

New way to estimate chalcid damage The alfalfa seed chalcid, an insect pest, is a particular problem in alfalfa grown for seed. Female chalcids lay eggs in developing alfalfa seeds. The growing larvae feed on, and destroy, the seeds as they mature.

A 5-year survey of alfalfa seed fields in Saskatchewan determined that

- the degree of infestation ranged from 0 to 35%
- infestation was correlated to management practices and several weather parameters
- the greatest damage to alfalfa was seen when summer weather was warm and dry, particularly in the preceding year.

A comparison of 14 cultivars indicated that certain cultivars were more susceptible to damage than others. Earlier- blooming cultivars may permit chalcid egg-laying earlier and over a longer period, leading to greater damage.

Increase forage productivity with proper phosphorus placement Using a special disc-banding technique on alfalfa stands can increase forage productivity by improving the effectiveness of phosphorus fertilizer. Although more expensive than surface broadcasting, banding, especially with narrowly spaced openers,

- produces additional returns of up to $38/ha
- may reduce the potential that phosphorus is lost in surface runoff, thus protecting the environment.

The greater revenue with banding more than covers its additional cost.

Monitoring herbicide-resistant weeds Since the late 1940s, farmers have been using chemicals to control weeds. Repeated use of herbicides has led to the development of resistant weeds that can survive herbicide application.

Wild oat populations resistant to herbicides with similar modes of action (single resistance) were identified in Manitoba in 1990. By 1994, a few populations were reported to be resistant to herbicides having different modes of action (multiple resistance). These populations were resistant to eight of the ten herbicides commonly used to control wild oat in wheat. Most disturbing, however, was the discovery of four fields in the northwestern region of the province that had wild oat resistance to all herbicides used in wheat.

The centre has established a comprehensive program to closely monitor the occurrence of multiple resistance in wild oats and other weeds in western Canada. The program includes

- ongoing risk-assessment studies to identify practices, such as the rate of herbicide application, that farmers can implement to lessen the risk of developing resistant weeds on their farms
- field experiments to investigate cost-effective strategies for preventing and managing herbicide-resistant weeds.

Brochures available to seed growers Individual guides on the seed production of 11 perennial grass species have recently been published as the product of a Canada–Saskatchewan Agriculture Green Plan project entitled "Development of sound production practices for seed production of native, forage and turf grasses." The guides compile research on these species. They will serve as a valuable source of information for present and future grass- seed growers.

Library holding of Green Plan final reports The Canada–Saskatchewan Agriculture Green Plan Agreement, which ran from 1993 to 1997, encouraged the adoption of more environmentally-friendly agricultural practices. Publications produced under the Green Plan are held at the library of the Prairie Farm Rehabilitation Administration at 1800 Hamilton Street, Regina, Sask. S4P 4L2. Some of these documents are also posted on the Internet at http://www.agr.ca/pfra/csagpae.htm.

New type of canola The species *Brassica juncea* is currently grown to produce condiment mustard. The centre collaborated with Saskatchewan Wheat Pool to develop a new *B. juncea*, called canola quality mustard, that produces canola oil. The first variety is expected to be launched in 1999.

Improved fall seeding with coated canola seed Fall seeding of canola has the advantages of

- producing greater yields
- maturing in early August, up to 12 days earlier than for spring-seeded canola
- producing seeds that tend to be larger and have a slightly higher oil content
- producing no green seed.

However, the seeding time is often only a few days, and the risks are high.

Saskatoon Research Centre researchers collaborated with Grow Tec Inc. of Nisku, Alta., to evaluate a polymer-coated canola seed for fall planting. Coated seed planted on 8 October 1997 and harvested in 1998

- produced about a 75% stand
- yielded 60–72 bushels per hectare.

Uncoated seed planted at the same time produced no plant stand. More polymer-coated seeds were planted in the fall of 1998.

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Mandate

The Semiarid Prairie Agricultural Research Centre (SPARC) is designated as a national centre for research on dryland farming systems, with a mandate to conduct research and development in

- resource (land) conservation
- cereals
- forages
- field crops.

The Land Resource Unit documents the state of the regional land resource base and conducts research on the dynamic factors that affect it, in order to

- develop and maintain current land resource databases
- provide interpretations of land-use suitability
- provide assessments of agri-environmental sustainability
- provide a basis for the regional application of research findings.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $9.5 million through their operating budget, $2.4 million from the Matching Investment Initiative, $203 thousand from other special programs, and $485 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services. Indian Head Experimental Farm, Regina, and the Land Resource Unit report to our research centre. The total land base includes

- 930 ha in Swift Current
- 490 ha in Indian Head
- 53 ha in Regina.

Facilities include a modern office–laboratory building equipped with

- controlled environment growth rooms
- greenhouses
- a salinity research lab
- a crop-services building
- a breeders' seed production and distribution centre at Indian Head
- a well-equipped machinery-design and prototype-production facility.

Achievements

- *Staff awards and honors*
- *Three new wheat varieties registered*
- *Improved disease resistance in wheat through genetic studies*
- *Rapid technique to assist breeding high-quality noodle wheat*
- *Crop rotation to reduce wheat leaf diseases*
- *New rye cultivar*
- *Rye as a valuable feed grain*
- *Method to reduce wheat-yield losses caused by salinity*
- *Best approach to deal with soil salinity*
- *Assessment of climate change in southwestern Saskatchewan*
- *Improved soil quality with green manure*
- *Carbon sequestration by soils*
- *Mechanical control of grassy weeds under conservation tillage*
- *Practices for managing leaf spotting diseases in spring wheat*
- *Computer simulation models of agricultural processes*
- *Development of native grass ecovars*
- *New recommendations on row spacing for forages*
- *New information from old records*

Staff awards and honors Dr. Con Campbell has received Canada's highest honor. He was inducted as a Member of the Order of Canada for his accomplishments in soil research. He also received Saskatchewan's highest honor, the Saskatchewan Order of Merit, for his contributions to the agriculture industry. Agriculture and Agri-Food Canada instated Dr. Campbell as a scientist emeritus for his continued outstanding contributions to the Research Branch.

Dr. Robert Zentner received the Agronomy Merit Award from Westco Fertilizers Ltd. for his practical contributions to the development of sustainable farming systems.

Dr. Wayne Lindwall received an Agriculture and Agri-Food Canada Agcellence Team Award for his leadership in greenhouse gas research.

Mr. Mark Stumborg received an Agriculture and Agri-Food Agcellence Team Award for his leadership in feasibility studies for the production and use of ethanol.

Dr. Ron DePauw received an Honorary Life Membership from the Canadian Seed Growers' Association in recognition of service to the Association and contribution to Canadian agriculture.

Three new wheat varieties registered The new varieties registered in 1998 have improved

- grain yield
- improved quality.

The varieties will contribute to the profitability and competitiveness of Canadian agriculture. They have been tendered to seed companies for distribution to producers.

AC Abbey Canada Western Red Spring (CWRS) is a sawfly-resistant (solid stem), semidwarf variety developed with the aid of producer checkoff funding. AC Abbey exhibits an outstanding combination of

- early maturity
- improved gluten strength
- no loss of protein.

It is the first semidwarf CWRS cultivar and the highest-yielding of the sawfly-resistant varieties.

Two durum varieties, AC Navigator and AC Pathfinder, developed under a collaborative agreement with Saskatchewan Wheat Pool, received interim registration for market evaluation with the Canadian Wheat Board. These new varieties will permit Canadian producers to compete in premium domestic and international markets. Compared with the predominant variety Kyle, AC Navigator and AC Pathfinder Canada Western Amber Durum showed

- shorter, stronger straw
- higher content of yellow pigment in the grain
- very strong gluten properties
- similar yield and protein.

Improved disease resistance in wheat through genetic studies Inheritance of common bunt resistance in doubled haploid and recombinant inbred line populations indicated that

- such populations are useful genetic tools
- resistance in the line SC8021V2 is controlled by one major and one minor gene.

The centre has released three wheat germplasm lines with common bunt resistance and two sets of near isogenic lines for resistance to loose smut for use by other scientists. These lines are useful in genetic and DNA marker studies

- to facilitate breeding of loose smut and bunt resistant cultivars
- to reduce the need for chemical seed treatments.

Rapid technique to assist breeding high-quality noodle wheat A rapid technique to measure the polyphenol oxidase (PPO) enzyme system was developed under a Matching Investment Initiative project with producer checkoff funding. PPO causes major end-use discoloration problems, especially in the noodle industry. This technology will facilitate breeding Canada Prairie Spring cultivars with improved noodle quality that will enhance the competitiveness of Canadian producers.

Crop rotation to reduce wheat leaf diseases In a study of leaf spot disease, researchers found that

- wheat grown continuously was less severely affected by the disease than wheat grown after summerfallow
- wheat grown after lentils was less severely affected than continuous wheat
- a deficiency of soil nitrogen caused greater severity of the disease in wet years.

This research, partially funded by the Saskatchewan Agricultural Development Fund, establishes standards for genetic resistance to leaf spots in new wheat cultivars to ensure that they are adapted to crop rotations used in western Canada.

New rye cultivar A new semidwarf rye cultivar, AC Remington, was developed in partnership with Proven Seeds and registered in 1998. AC Remington shows improved

- grain yield
- test weight
- kernel weight
- protein and starch properties.

Rye as a valuable feed grain Rye with low amounts of grain pentosan shows superior feeding quality. Experimental low-pentosan lines are being tested in advanced yield tests. This rye will be a valuable feed grain for the expanding prairie livestock industry in light of these improvements in quality combined with rye's

- winter hardiness
- disease resistance
- high yield.

Method to reduce wheat-yield losses caused by salinity Soil salinity in the plant-root zone reduces the grain yield of spring wheat mainly by preventing the initiation and growth of plant tillers. One possible way to overcome this limitation is to increase the number of plants grown per unit area, thereby increasing the number of more-resistant main stems. Such a study was done with Katepwa wheat. It showed that, for this practice to be effective, plant populations would have to increase to such numbers that plant competition for water in unirrigated, semiarid climates would still limit production during most years.

Best approach to deal with soil salinity Soil salinity affects up to one-quarter of cropland on the prairies. So developing more salt-tolerant plant strains is key to minimizing economic losses due to salinity. One of the strategies for coping with salinity is to develop plant tissue with greater salt tolerance. After trying this approach, which relates crop growth to root-zone salinity, researchers concluded that

- plant physiological processes were insufficiently understood
- the best approach to managing soil salinity is selecting strains that show natural tolerance.

Assessment of climate change in southwestern Saskatchewan Compared with the 1950s and 1960s, in southwestern Saskatchewan today

- winter and spring temperatures are warmer
- snowfall amounts are decreasing
- spring runoff starts earlier
- as temperatures increase, the proportion of rain increases
- producers can begin seeding earlier.

In the 1990s producers have been able to seed fields in April. On the same date in the 1960s, these fields were frozen and snow covered. There are many ways for producers to adapt to climate change, such as earlier seeding. Thus, climate change may not necessarily threaten the Canadian food supply or the economic viability of the agri-food sector.

Improved soil quality with green manure
Researchers tested the following four annual legumes as green manure for partial fallow substitution on a Brown loam in southwestern Saskatchewan:
- black lentil
- Tangier flat pea
- chickling vetch
- feed pea.

It was found that the legumes
- contributed biologically fixed nitrogen to the soil
- substantially improved soil quality relative to the commonly used tilled fallow–wheat cropping

Also, it was found that the quality of legume dry matter was proportionally more important than its quantity.

Annual legumes provide a tool for improving soil fertility and quality in sustainable agricultural production systems, thus lessening the dependency of agriculture on chemical fertilizer and fossil fuels.

Carbon sequestration by soils Carbon dioxide (CO_2) in the atmosphere is increasing at a rate of about 0.5% per year. Because atmospheric CO_2 may be responsible for one-half of the so-called global warming effect, Canada has committed to reducing the amount of CO_2 emissions to the atmosphere as a means to reduce human-made impacts on climate change.

Adoption of best management practices that increase soil organic matter at the farm level could meet a substantial proportion of Canada's international commitment to reduce CO_2 emissions. Properly managed agricultural soils could sequester as much as 14 million tonnes of CO_2 every year for the next 20 years.

With private and public partners and Matching Investment Initiative support, researchers have shown how
- adopting better farming systems enhances carbon sequestration by soils
- methodologies and performance indicators can be provided so that Canada may include agricultural soil sinks in meeting emission reduction targets.

The amount of CO_2 derived from decomposing crop residues depends on
- the soil moisture regime
- the placement of the straw in the soil.

Unless best management practices (e.g., proper fertilization and adequate mixture of crops in a crop rotation) are used in conjunction with conservation tillage, the sequestration benefits of these tillage systems will not be realized.

Increased water conservation with direct seeding increases
- primary production
- soil organic matter.

But it may also increase soil organic matter decomposition, lowering the amount of soil organic matter. Thus, in some soils, carbon sequestration may not always increase when zero tillage or direct seeding is adopted.

The use of indicators of soil quality to assess the influence of soil management on soil organic matter content requires defining
- spatial dependencies (spatial variability)
- cause–effect relationships between the indicators and the processes and mechanisms determining soil organic matter quantity and quality.

Mechanical control of grassy weeds under conservation tillage As more producers continue to adopt conservation tillage practices and reduce fallowing frequency, there is the concern that grassy weed infestation may become a limiting factor. The effects of using preseeding tillage for 3 years after 9 years of zero tillage showed that there were no deleterious effects on soil quality parameters. Thus, farmers that adopt conservation tillage can, from time to time, employ preseeding tillage to control grassy weeds that are otherwise difficult to control with expensive herbicides.

Practices for managing leaf spotting diseases in spring wheat In recent years, spring wheat grown in Canada has suffered a large increase in the incidence of leaf spotting diseases, such as
- tan spot
- stagnospora blotch
- septoria blotch.

At present, all registered wheat cultivars are susceptible to these diseases.

A 4-year study was conducted in the Brown soil zone. Results indicated that disease severity was greater in

- wheat grown after fallow, compared with wheat continuously grown in a monoculture
- wheat grown after a noncereal crop
- crops grown under nitrogen-deficient conditions in years with a dry summer
- crops grown under phosphorus-deficient conditions in years with a cool and wet spring.

The results of this study indicated that the same best management practices that foster accumulation of soil organic matter also reduce the severity of leaf spotting diseases. These practices include

- reduction of fallow frequency
- diversified crop rotations
- adequate fertilization.

Computer simulation models of agricultural processes Computer simulation models are important for enhancing our knowledge and understanding of

- complex and dynamic processes affecting agricultural production
- the impact of agriculture in environmental quality and sustainability.

Two simulation models, EPIC (Environmental Policy Integrated Climate) and CENTURY, were used

- to assess the effects of agricultural practices on long-term resource sustainability and profitability at the farm level
- to validate the suitability of these models as a resource management tool.

The CENTURY simulation model was used to predict changes in soil organic matter under wheat rotations with different frequencies of summerfallow and under a cereal–hay rotation. It predicted that soil organic matter increases as a result of

- more intensive cropping
- less tillage
- reduced soil erosion.

The model's predictions were within 10% of measured values collected over decades from long-term crop rotation experiments at four locations in western Canada.

The model further predicted that

- grain yield will increase by 86–840 kg/ha
- it will take the soil from 12 to 46 years to reach a new steady-state equilibrium.

This simulation supports the present trend toward more sustainable agricultural production resulting from the adoption of extended crop rotations in combination with minimum and zero tillage management practices and proper fertilization.

The EPIC model integrates many important aspects:

- soil management
- crop management
- weather
- economics.

EPIC provided accurate and precise estimates of long-term yield and soil quality trends, but less-than-satisfactory estimates of annual yield variability. Before being widely applied to predicting short-term yield trends under semiarid prairie conditions, the model requires further improvements, particularly related to

- processes affecting soil water balance
- the distribution of soil water in the profile.

Development of native grass ecovars The first breeder seed of native grass ecovars (ecological varieties) was established at the Seed Increase Unit of the Indian Head Research Farm. Three ecovars are being produced:

- rough fescue
- little bluestem
- awned wheatgrass.

This production will provide seed for release to Ducks Unlimited Canada (DUC) under the ecovar development project funded by that agency and the Matching Investment Initiative. Ecovars will be used for waterfowl habitat restoration and reclamation by DUC and other conservation agencies across the prairie region of western Canada.

New recommendations on row spacing for forages The centre has provided new recommendations to forage producers about the impact of row spacing at the time of forage establishment. Previous research was based on a biased estimate of forage biomass. The new recommendations

- are more consistent with ecological principles
- promote the sustainability of long-term seeded

pastures in the semiarid prairie region.

New information from old records Modelers and agronomists have new information about the relationship between weather and the forage yield of dryland alfalfa for the semiarid prairie. Alfalfa forage yield becomes more dependent on weather during the growing season as the stand matures. This trend is attributed to the use of deep soil water by young stands of alfalfa. A historical database for the yield of Rambler alfalfa was constructed from long-term records and published articles, and then related to weather variables.

Research Publications

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Mandate

The Lethbridge Research Centre (LRC)

- develops new and improved technology to
  - increase the efficiency of beef production and beef quality
  - enhance the competitiveness and sales of Canadian beef in world markets
- develops sustainable and profitable production systems for dry and irrigated cultivated land and rangeland in the southern Canadian prairies
- transfers new technology to the agricultural industry.

Resources

The Lethbridge Research Centre conducts research at its main centre near Lethbridge, Alta., a research ranch at Kamloops, B.C., and field sites at Onefour, Stavely, and Vauxhall, Alta. The Alberta Land Resources Unit, which operates out of Edmonton and conducts soil classification and land-use studies in Alberta, also reports to the centre.

The main centre, located in the Agriculture Centre, shares its facility with the regional office of Alberta Agriculture Food and Rural Development and the Canadian Food Inspection Agency. It has an immediate land area of 500 ha. Additional land area at the filed sites is:

- a 17 000-ha beef cattle ranch near Manyberries
- a 400-ha ranch near Stavely in the foothills of the Rocky Mountains
- a 130-ha irrigation substation at Vauxhall.

The Kamloops Range Research Ranch has a land base that includes

- 57 ha of irrigated land
- 470 ha of forested rangeland
- 40 000 ha of provincial rangeland.

In 1997–1998, when the achievements presented in this report were completed, the centre spent $18.9 million through their operating budget, $6.6 million from the Matching Investment Initiative, $858 thousand from other special programs, and $1.3 million in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

Achievements

- *Staff awards and honors*
- *New technique to measure greenhouse gas*
- *New techniques to measure ammonia emissions*
- *Assessment of herbicide losses*
- *Assessment of dry bean*
- *Two new bean cultivars*
- *New detection methods for potato disease*
- *Potato gene resistant to common wilt disease*
- *Virus-resistant potato*
- *Transgenic potatoes*
- *Assessment of stork's-bill effects*
- *Weed control for peas*
- *New herbicide-spraying technology*
- *Evaluation of herbicide for downy brome*
- *Biological control of weeds: National weed control program*
- *Biological control of leafy spurge*
- *New biocontrol agent for hound's-tongue*
- *Evaluation of potential biocontrol for thistle*
- *Assessment of water sources for range cattle*
- *New range management technique for cattle toxins*
- *Control of grasshoppers*
- *Protozoan controls against grasshoppers not promising*
- *New equations to predict insect warmth*
- *New timing for biocontrol application*
- *New method to avoid bird poisoning*
- *Better timing for adminstering invermectin*
- *Wasp as biocontrol for biting flies on livestock*
- *Compound to promote rumen fermentation in livestock*
- *Livestock management to prevent surface-water contamination*
- *Nutrition: New methods to reduce bloating*
- *Improved feeding efficiency with silage oculant*
- *New feed enzyme technology*
- *Cheaper feed costs for cow–calf production*
- *Hormone treatment to improve bull reproductive performance*
- *Studies on estrus synchronization*
- *New method for insemination*
- *Assessment of alternative hormone*
- *New test for viral disease in chickens*
- *New immune test for swine*
- *Visiting Scientist Program*
- *Neural networks modeling*

Achievements

Staff awards and honors Dr. Peter Harris was inducted into the Order of Canada on 4 February 1998 in recognition of his contribution to the country through his research into the biological control of weeds.

New technique to measure greenhouse gas Canada is committed through the Kyoto Agreement to reducing the production of greenhouse gases to 6% below 1990 levels. LRC researchers have developed new techniques to

- continuously monitor the emission of CO_2 from soils
- assess the amount of C stored in soil organic matter.

These will be used to provide benchmarks for agriculture's contribution to greenhouse-gas production and assist farmers in developing management practices to enhance C storage in the soil and so improve soil quality.

New techniques to monitor ammonia emissions Ammonia lost from manure into the air

- causes problem odors that could curtail expansion of the feedlot industry
- represents a considerable loss of nitrogen that could better be used in crop production.

LRC researchers have developed new techniques to monitor ammonia emissions in agriculture.

Assessment of herbicide losses Airborne herbicides may create problems for humans by ending up

- in drinking water
- on dust that is breathed in.

LRC researchers found that
- herbicide losses resulting from wind erosion were more than 30 times higher than losses caused by water runoff
- an average 4.5% of four different surface applied herbicides was transported on wind-eroded sediment.

These findings are of particular concern in southern Alberta, where Chinook winds and freeze–thaw winters can combine to create erosion-prone conditions.

The best prevention includes
- managing soils to prevent erosion
- avoiding the application of large amounts of herbicide on erosion-prone soils.

Assessment of dry bean AC Skipper navy bean, registered in 1995, is finding a niche west of Morden to Brandon, Man. The shorter season in this area makes early-maturing varieties more needed than in the higher-heat unit areas of Manitoba. Field performance in 1997 and 1998 was promising.

Two new bean cultivars LRC registered two new bean cultivars in 1998, AC Earlired and AC Alberta Pink. AC Earlired, a small red (red mexican) bean, compares favorably with the standard NW63 by
- maturing up to 5 days earlier
- matching its yield.

The risk of fall frost damage is thus greatly reduced. If farm-scale tests planned for 1999 are successful, this cultivar could become the dominant small red for southern Alberta.

Compared with the standard Viva, AC Alberta Pink
- matures slightly ahead
- exceeds in yield by more than 10%
- has a larger seed size.

Farm-scale tests in 1999, together with test marketing, will help determine its niche.

The centre has
- produced "breeder seed" and "foundation seed" for these cultivars
- signed licensing agreements with the Alberta Pool Bean Business Unit, Agricore.

New detection methods for potato disease Research in potato pathology has resulted in the
- discovery of fungicide-resistant storage rots
- development of sensitive detection procedures that reduce the threat of new diseases.

These developments will help producers avoid potential disasters and save many thousands of dollars.

Potato gene resistant to common wilt disease The discovery of a gene in potato that provides immunity to a common wilt disease will make varieties more competitive by improving
- yield
- quality.

A DNA marker developed to a related gene in tomato is already being used by several seed companies to develop new varieties resistant to the wilt disease.

Virus-resistant potato LRC researchers have developed a new virus-resistant potato that
- has less internal brown streaking in the tuber
- needs less culling to produce high-quality french fries
- requires less pesticide to control the disease vector, reducing costs and pesticide loads on the environment.

Transgenic potatoes Potatoes could become the manufacturing factory of the future. LRC researchers have developed transgenic potatoes that produce valuable enzymes for the livestock industry. Nonfood uses of agricultural products will expand in the future and provide opportunities for producers to meet niche-market demands.

Assessment of stork's-bill effects Stork's-bill is becoming a common weed in several crops in southern Alberta. LRC researchers measured its effect on crop yield and found that at common densities, it caused yield reductions of
- 36% in wheat
- 37% in canola
- 82% in dry bean
- 92% in pea.

Management procedures to control stork's-bill in conservation tillage systems have been developed and transferred to producers.

Weed control for peas Control of grassy and broad-leaved weeds has been a problem for direct-seeded peas. Researchers have found that Imazamox can provide growers with superior postemergent control of these weeds.

New herbicide-spraying technology Reducing the amount of herbicide usage while maintaining an effective control of weeds has been a core goal of the field crops program. The Detectspray system, which delivers herbicide directly to detected weeds rather than on the field as a whole, reduced herbicide usage by

- 9–60% (depending on weed population) on fallow fields, saving $4–$32/ha in chemical costs
- 50–80% in the postharvest control of quackgrass and thistle, saving $16–$50/ha in chemical costs.

This technology has the potential to

- reduce herbicide input into the environment
- allow more cost-effective weed control in agricultural systems.

The centre has advised growers and commercial applicators of the most important biological and environmental factors affecting the effectiveness of this new spraying technology.

Evaluation of herbicide for downy brome Downy brome is an important weed in winter wheat. There is currently no herbicide available to control it effectively. Working in partnership with industry, LRC researchers found that using MON 37500

- provides effective control of this weed
- will likely encourage greater adoption of conservation-tillage winter wheat production on the Canadian prairies.

Biological control of weeds: National weed control program Biological control of weeds provides an alternative to traditional herbicides with minimum environmental risk. LRC coordinates a national weed biocontrol program. In general this program involves developing species-specific weed control that is cost effective in the development phase and, once in place, requires little additional inputs.

Agriculture and Agri-Food Canada has introduced more than 60 insect species to control noxious weeds since 1952. Some are widely used today for weed control in Canada and the United States. The potential savings in chemical and other control costs amount to many millions of dollars each year.

In Canada, insects now control

- St. John's wort in British Columbia
- tansy ragwort in British Columbia and the Maritimes
- nodding thistle across Canada.

They are also starting to have an effect on

- diffuse and spotted knapweeds in British Columbia
- leafy spurge in the Prairie Provinces
- purple loosestrife in Ontario.

Biological control of leafy spurge The centre has a collaborative project with the Blood Tribe for the biological control of 3500 ha of leafy spurge on reserve land. Suppression of leafy spurge using released biological control agents will enable

- reclamation of grazing lands
- protection of the investment in the Blood Tribe Irrigation project.

Researchers released European black-dotted beetles, *Aphthonia nigriscuitis* and flat-black beetles, *A. lacertosa* known to feed on leafy spurge at more than 100 sites on the reserve. A recent survey showed that the beetles are established at 98% of the release plots, in which 85% of the spurge has visible damage.

New biocontrol agent for hound's-tongue Hound's-tongue is widespread throughout at least 2000 ha in British Columbia's southern interior. This weed

- hinders the establishment of forage
- produces burrs that irritate cattle and can reduce their market value
- is highly toxic and can cause poisoning.

The centre has released a new biocontrol agent, a beetle, to control hound's-tongue in British Columbia. The beetle's larvae damage hound's-tongue by feeding on the weed's roots. This damage

- affects the weed's chances of survival during times of drought
- diminishes the energy reserves of attacked plants
- ultimately reduces both survival rates and seed production.

The biocontrol beetle was approved for release by the Canadian Food Inspection Agency on 24 June 1998.

Evaluation of potential biocontrol for thistle A beetle from China has the potential to control Canada thistle. To predict the success and range of this beetle in Canada, LRC researchers applied methods of

- insect population modeling
- geographic analysis.

Assessment of water sources for range cattle Several years of research have shown that the source of water used by range cattle affects their performance. As a result of this work, ranchers are providing cattle with fresh water rather than allowing cattle direct access to dugouts. This change

- benefits cattle performance
- reduces the number of dugouts with poor- or low-quality water.

New range management techniques for cattle toxins Toxic plants, such as timber milkvetch *Astragalus miser* var. *serotinus*, that grow on forested range in British Columbia cause reduced production and death when ingested by cattle. Annual Canadian losses are estimated to be $3–$5 million per year. Work is under way to identify the toxins. Meanwhile, LRC researchers have developed new ways to manage toxicity in cattle, such as by providing

- protein blocks
- a new strain of rumen bacteria that degrades the toxins.

These treatments have been transferred to industry.

Control of grasshoppers Localized outbreaks of grasshoppers occur every year on the prairies, and the threat of an extensive outbreak is always present. Effective biological control as part of an integrated pest-management system would provide a more natural means of reducing grasshopper numbers.

Beauveria bassiana, a disease agent, is known to kill grasshoppers but is not effective in the field. In studying why this is so, LRC researchers looked at how the agent's ability to control grasshoppers was affected by

- temperature
- sunlight.

One way to overcome the constraints posed by temperature is to introduce another pathogenic species in combination with *Beauveria*. Researchers mixed a cool-temperature disease agent with a warm-temperature agent and found that the mixture works better than either agent alone.

Protozoan controls against grasshoppers not promising Some protozoa are pathogens of insects. Infected insects die slowly, and their feeding rate is reduced. Researchers have reviewed the results of studies that looked at developing these microbes as control agents against grasshoppers and locust. *Nosema locustae*, the most promising protozoa for microbial control of grasshoppers, has shown low virulence and poor effectiveness. Even consecutive years of treatment with this protozoa does not solve the problem.

New equations to predict insect warmth Body temperature of grasshoppers is important in their development and ability to combat infectious biocontrol agents. LRC researchers developed equations to predict

- how warm insects become when basking in sunlight
- the effect of wind on their body temperature.

These factors are important in determining the effectiveness of new methods of grasshopper control.

New timing for biocontrol application LRC researchers have found that grasshoppers are susceptible to infection by soil-borne biocontrol agents when they lay their eggs in soil. This finding will help in refining methods of control use.

New method to avoid bird poisoning LRC researchers have developed a field method to determine how the toxic effects of grasshopper insecticides on grassland birds can be monitored and avoided. These effects may be

- direct (i.e., result in death)
- indirect (e.g., cause starvation).

Better timing for administering invermectin to livestock Ivermectin is a chemical treatment for the control of internal and external parasites in cattle. However, researchers have found that ivermectin reduces the number of beneficial insects that degrade cattle dung on pastures and rangeland. Accumulated dung on pasture

- reduces biomass productivity
- acts as a breeding site for pestiferous flies.

Researchers found that ivermectin has a much lower impact on dung beetles if administered to cattle after insect activity peaks in late spring and early summer.

Wasp as biocontrol for biting flies on livestock A 2-year survey of feedlots across Alberta has identified a naturally occurring parasitic wasp with potential as a biological control tool against biting flies that attack cattle. *Trichomalopsis sarcophagae* is a tiny native wasp that kills

- stable flies, which cost feedlot operators in the province an estimated $7 million in lost production each year
- house flies, a nuisance pest for people near feedlots.

If further study is successful, the wasp could be commercially available as a control option to producers within 5 years.

Compound to promote rumen fermentation in livestock LRC researchers have found that a natural plant compound from yucca causes many of the desirable changes in ruminal fermentation that are now achieved through the use of ionophore antibiotics. The yucca compound was found to

- lower ammonia concentrations in the rumen
- virtually eliminate rumen protozoa that cause inefficiencies in nitrogen metabolism
- favorably alter the levels of volatile fatty acids, with increased production of gluconeogenic propionate.

These findings support a more natural production of food, helping to meet the growing expectations of consumers.

Livestock management to prevent surface-water contamination The livestock industry has been implicated as a source of chemical and biological contaminants of water supplies. Two microorganisms that live in cattle and cause concern for human health are

- *Giardia*
- *Cryptosporidium.*

Researchers found that more than 80% of calves in the ecologically sensitive region of the Fraser Valley, B.C., were infected with *Giardia*, which persisted throughout the period of study. In contrast, *Cryptosporidium* was eliminated within a 6-week period. Several management strategies have been proposed to prevent contamination of surface water with these microorganisms.

Nutrition: New methods to reduce bloating Bloat is an inability to release gas produced from the digestion of feed in the rumen. Cattle will die from it unless treated. Bloat occurs in cattle that

- graze alfalfa
- are fed rapidly digestible, high-energy diets in the feedlot.

The occurrence of bloat is not well understood despite many years of research world-wide. Research conducted at the centre indicates the effective control of feedlot bloat can be provided by

- level of grain processing
- use of ionophores and other additives.

LRC researchers have collaborated with colleagues at the Saskatoon Research Centre to develop a bloat-reduced alfalfa cultivar, AC Grazeland. This cultivar will greatly reduce the risk of bloat in cattle grazing on alfalfa.

Improved feeding efficiency with silage inoculant Silage is a major feed component in the feedlot industry in western Canada. Enhancing the microbial inoculant responsible for the fermentation of silage can improve feed efficiencies in the livestock industry.

LRC researchers inoculated alfalfa silage with two bacterial inoculants:

- one containing mixtures of *Lactobacillus plantarum* and *Enterococcus faecium*
- one containing only *L. plantarum.*

Both increased the dry matter intake of lambs.

Compared with feedlot cattle fed uninoculated silage, those fed silage with the multiple-species inoculant showed improved

- nitrogen digestion and retention
- average daily gain (by 14%)
- feed efficiency (by 6%).

New feed enzyme technology Feed enzyme technology is a major advance in animal feeding. LRC researchers have developed and patented an enzyme technology. Under typical feedlot conditions, this new technology boosts by 8–10% both

- cattle-feed efficiency
- average daily gain or milk yield.

Preliminary benefit–cost analysis shows

- about a 2:1 benefit for beef cattle, on top of other performance boosters such as ionophores

and implants
- a 4:1 benefit for dairy cows.

The procedure works well for effective enzyme formulations containing xylanase and cellulase in the appropriate ratios. It works by establishing a complex between the enzyme mix and the feed before it enters the animal, ensuring stable feed-enzyme activity in the rumen.

Cheaper feed costs for cow–calf production Feed is a major cost of cow–calf production, yet adequate nutrition is required for optimum reproductive performance. LRC researchers examined the impact of energy level in heifer diets on reproduction. Starting at calving, beef heifers were fed a diet with a forage-to-concentrate ratio of either
- 80:20
- 50:50.

Digestion and reproductive performance were minimally affected by diet. Because concentrates are often a cheaper source of energy than forages, limit-feeding a diet with higher concentrates should result in more profitable cow–calf production.

Hormone treatment to improve bull reproductive performance Many bulls are infertile, resulting in
- lower pregnancy rates in the herd
- reduced production efficiency.

New methods are needed to improve the accuracy of predicting sperm production and quality in bulls.

LRC researchers treated mature bulls with gonadotropin-releasing hormone. As a result, they were better able to predict
- the number of spermatozoa
- percentage live spermatozoa
- percentage motile spermatozoa.

Studies on estrus synchronization Improved estrus synchronization in beef and dairy cows offers the advantage of
- facilitating artificial insemination
- shortening the calving season
- hastening reproductive cycles in virgin heifers and after calving.

These advantages lead to
- increased uniformity in the calf crop
- increased value at the time of sale.

LRC researchers examined the effects of increasing the dose of Melengestrol acetate (MGA). They found that
- daily increases from 0.5 to 1.0 mg/head did not improve MGA's efficacy in synchronizing estrus
- feeding MGA for 6 or 7 days, starting 7–9 days after insemination, may improve pregnancy rates.

New method for insemination A new regime for timed insemination of dairy cattle uses gonadotropin-releasing hormone (GnRH), prostaglandin, and a second dose of GnRH. Cloprostenol (prostaglandin) given to lactating holsteins 6 days after GnRH resulted in relatively synchronous ovulation, even in the absence of a second dose of GnRH.

Assessment of alternative hormone Estradiol 17-beta effectively synchronizes emergence of a new wave of ovarian follicles and follicle ovulation in cows but is not commercially available. A test of a similar, commercially available preparation, estradiol cypionate (ECP), showed that ECP is far less efficacious than estradiol 17-beta for this purpose.

New test for viral disease in chickens Chicken breeders can now select for healthier chickens using locus-specific tests for endogenous viral elements. Chickens selected in this way
- are capable of improved productivity
- yield a more wholesome end product, with a reduced incidence of viral contamination.

New immune test for swine Swine immunologists have developed a quantitative test for porcine interferon-gamma. This test is one component of a battery of molecular assays they are developing to help them understand the way the pig immune system works. The ultimate aim is to select for pigs that
- stay healthier longer
- retain the ability to produce efficiently even when exposed to pathogens.

Visiting Scientist Program The centre created a Visiting Scientist Program to garner expertise in livestock production and manure management. This program has helped promote best management practices to sustain

- soil quality
- water quality
- animal ethics.

Two private feedlots of 12 000 head volunteered their operations for detailed testing and recommendations, and offered sites for meetings. At these meetings, experts on manure management and animal ethics shared their experience with prairie producers. The message on animal ethics was that the mainstream of society is demanding humane treatment of farm animals being raised for food, milk, and fiber.

Neural networks modeling Researchers have developed artificial intelligence, or neural network modeling, to predict

- the time of seeding
- the time of harvest
- toughness of carcasses
- seed quality
- successful release site for insects for weed biocontrol.

There are many benefits of neural nets. For example, neural net modeling of harvest date will help the Canadian Wheat Board allocate grain cars, with the potential of saving millions of dollars annually.

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**Alberta-Canada Barley Agreement, Lacombe Research Centre

Mandate

The Lacombe Research Centre (LRC) has a national mandate to conduct research on

- ante- and post-mortem factors that influence meat yield, quality, safety, and preservation
- apiculture.

With its affiliated sites and research partners, the centre also develops integrated, sustainable crop- and animal-production systems and crop varieties for the short-season environments of the Parkland and northwestern Canada.

Resources

In 1997–1998, when the achievements presented in this report were completed, the centre spent $8.4 million through their operating budget, $2.3 million from the Matching Investment Initiative, $4 thousand from other special programs, and $951 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

The centre's lead site is located in Lacombe, Alta., between Edmonton and Calgary, on 808 ha of land. It has facilities for raising beef cattle and hogs, and a meat research facility that includes:

- a holding barn
- an abattoir
- a blast chiller and coolers
- a cutting room
- a taste-panel kitchen and sensory analysis booths.

Other facilities at the site include
- greenhouse, plant-growth chambers, dryers, threshers, and seed storage
- laboratories
- offices.

Affiliated with Lacombe are the Beaverlodge Research Farm and the Fort Vermilion Field Site. Beaverlodge controls 360 ha of land at two sites and rents about 35 ha of land a year for research. The Fort Vermilion Field Site, operated during the growing season, owns 187 ha of land and rents about 3 ha of land for research.

The centre has advisory committees comprising leaders from
- industry
- government
- universities
- commodity groups
- the farming community.

The centre supplements its resources with research grants and in-kind grants from provincial governments, producer groups, the meat-processing industry, and agri-business. It is active in the release of plant varieties and the commercialization of technologies developed through their research.

Achievements

- ***Staff awards and honors***
- ***Triticale: An alternative swine feed***
- ***Leaner pigs with CLA in diet***
- ***Successful lamb marketing***
- ***New suspension method to improve beef tenderness***
- ***Postmortem prediction of beef tenderness***
- ***New method to rate meat texture***
- ***Better timing for feed withdrawal in pigs***
- ***Identification of agent limiting long-term storage of beef***
- ***Evaluation of marbling in live cattle***
- ***Survey of weed populations in pasture***
- ***Comparison of herbicide-tolerant canolas***
- ***Better timing for weed removal in peas***
- ***More diverse microbial communities***
- ***Inactivation of herbicides by soil***
- ***Management to prevent barley scald***
- ***Management to reduce barley disease***

Staff awards and honors M.A. Arshad was elected a Fellow of the Canadian Society of Soil Science for his outstanding contributions to the field of soil science through fundamental research with practical application to crop production. Dr. Arshad has demonstrated exceptional leadership and has ably taught and mentored young scientists.

D.R.C. Bailey received an Agcellence Award for his contribution to the Ethanol Management Committee.

C.O. Gill and Stanfos Inc. of Edmonton were awarded the Canadian Institute of Food Science and Technology's Gordon George Maybee Award for applied development in the food industry. Dr. Gill and Stanfos Inc. developed effective, low-cost carcass pasteurization units for the meat industry.

D.H. McCartney received an Agcellence Award for his contribution to the AC Grazeland alfalfa team.

A.L. Schaefer received an Agcellence Award for his excellence and outstanding contributions to Agriculture and Agri-Food Canada and to the agri-food industry. Dr. Schaefer developed noninvasive methods of measuring animal stress and electrolyte therapy treatments to alleviate animal stress.

Triticale: An alternative swine feed Compared with other cereal crops, spring triticale shows superior drought tolerance, making it an attractive crop in lower-rainfall areas of the Canadian prairies. Triticale is often well-priced in the marketplace, and swine producers have asked whether it can be substituted for other cereals in swine rations.

Research results indicate that the triticale cultivar Pronghorn can be successfully substituted for corn or hulless barley in the diet of growing–finishing (25–100 kg) pigs without deleterious effects on

- live animal performance
- carcass composition
- meat quality.

Leaner pigs with CLA in diet Feeding fat to pigs tends to fatten them. This may not be true when the fat is conjugated linoleic acid (CLA), which has some newly identified metabolic properties. Compared with finisher pigs fed a 2% sunflower-oil diet, those fed a 2% CLA diet

- had 6.8% less subcutaneous fat
- had 2.3% more lean
- had loins with 0.38% more marbling fat
- tended to consume less feed
- gained weight at a similar rate
- showed the potential for improved quality and palatability because of greater marbling fat.

CLA holds promise for the swine industry by improving carcass composition and quality while potentially reducing production costs.

Successful lamb marketing Lambs should be marketed between 6 and 12 months of age and at 50–68 kg in order to

- maximize consumer acceptance
- increase market share
- improve profitiability.

New suspension method to improve beef tenderness Traditional processing of beef carcasses allows considerable rigor shortening in the loin and major muscles of the hind limb. Alterations to the hanging carcass were made to reduce rigor-related toughening. This change resulted in

- improved tenderness, shown by significant decreases in shear force (a decrease of 0.65 for rib-eye and 2.11 kg for loin muscle)
- reduced yield and quality grades, because of a change in conformation at the grade site.

Hence, despite significant improvements to tenderness, this procedure cannot be recommended to industry until its effects on yield and quality grades can be addressed.

Postmortem prediction of beef tenderness Attempts to accurately predict tenderness early postmortem utilizing incubated meat samples were not satisfactory. LRC researchers found that

- only 15% of the variation in shear could be accounted for using incubated samples
- the rate of change in shear force between 0 and 1 day postmortem was significantly related to shear forces at 24 days.

Further study showed that categorization of shear forces at 1 day postmortem accurately classified 77% of the carcasses into tenderness categories at 7 days postmortem. Thus, categorization appears to hold the greatest potential for reducing the proportion of unacceptably tough carcasses.

New method to rate meat texture The correlation between objective measures of tenderness (Warner–Bratzler shear) and subjective measures of tenderness (taste panel) tends to be rather low. However, objective measures of tenderness are routinely used more than subjective measures because they

- are less costly
- require less time per sample.

A new cyclical texture profile analysis procedure that simulates human chewing is being developed. The procedure will generate values for

- hardness
- chewiness
- springiness
- resilience
- cohesiveness.

This procedure should be a more accurate, cost-effective measure of tenderness if it correlates well with taste panel data.

Better timing for feed withdrawal in pigs The numbers of *Escherichia coli* biotype 1 are an indicator of the potential for presence of pathogens in pigs. LRC researchers found the highest counts of this bacteria in the caecum of pigs whose feed had been withdrawn at the piggery 15 h prior to transport to the abattoir, compared with pigs

- with no feed withdrawal
- whose feed was withdrawn at the abattoir for 15 h after transport.

Researchers concluded that withdrawl of feed before slaughter should

- be as short as is practical
- precede transport if possible.

Identification of agent limiting long-term storage of beef In a study of flavor deterioration in beef steaks, LRC researchers stored steaks in 100% carbon dioxide at 2°C for up to 10 weeks and then displayed them aerobically for 28 h at 8.6°C in a retail case. Flavor deterioration during this time was related to the growth of a subpopulation of aciduric lactic acid bacteria.

LRC researchers found that
- most of the lactic acid bacteria present when the steaks spoiled were aciduric lactic acid bacteria
- the bacteria were *Lactobacillus* spp.
- spoilage occurred after 7–8 weeks of storage
- freezing the steaks after storage in carbon dioxide accelerated their deterioration by about 2 weeks.

Evaluation of marbling in live cattle A Windows-based Computer Vision System captures cross-sectional ultrasound images of live cattle. These images are used to predict
- back fat thickness
- rib-eye marbling

This real-time ultrasound system
- permits voice input for animal identification and other information
- traces the rib-eye area semiautomatically by identifying a few critical boundary points
- predicts marbling by using neural network analysis.

Survey of weed populations in pasture LRC researchers monitored weed populations as part of a grazing study during 1994 to 1997. They found that
- weed populations increased only in perennial smooth bromegrass and meadow bromegrass pastures that were extensively grazed
- shepherd's-purse and other annual species were dominant in the annual pastures comprised of spring-planted winter triticale and a winter triticale–barley mixture
- dandelions were dominant in the perennial pastures.

Researchers concluded that weeds grow in pastures that parallel their life cycles (annual or perennial). Where pasture is required for long periods, rotations between annual and perennial pastures would diversify the selection pressure enough so that no particular weed community could dominate the sward.

Comparison of herbicide-tolerant canolas Growing herbicide-tolerant canolas could be advantageous when "difficult weeds" are present. LRC researchers compared the effectiveness of a standard postemergence weed-control system with three herbicide-tolerant canola cultivars:
- Roundup Ready
- Liberty Link
- Canola Smart.

The yield of the herbicide-tolerant varieties at several western sites was related more to the level of weed control achieved with the respective herbicides than to the inherent yield potential of the varieties under weed-free conditions.

Better timing for weed removal in peas At Lacombe and Lethbridge, weeds removed more than 2 weeks after pea emergence usually caused significant yield losses. Peas sometimes lost almost half their potential yield when weed control was delayed to 4 or 5 weeks after crop emergence. Herbicides should be applied early, when crops have maximum yield potential.

More diverse microbial communities A diverse microbial community ensures the proper function of important soil processes, including
- nutrient cycling
- maintenance of soil structure
- degradation of agro-chemicals and pollutants
- control of plant diseases.

Conservation tillage and legume-based crop rotations support diverse soil microbial communities and contribute to the sustainability of agriculture ecosystems. LRC researchers found that
- microbial diversity was significantly higher under wheat grown after red clover used as green manure or field pea than under wheat grown after wheat or summerfallow
- the bacterial community structures were more diverse under zero tillage than under conventional tillage.

It is more prudent to adopt cropping and tillage practices that preserve or restore microbial diversity than to persist with practices that diminish diversity.

Inactivation of herbicides by soil Sorption is one of the key processes controlling the bioavailability and mobility of agrochemicals in soil systems. Sorption of agrochemicals on the soil matrix can be affected by physical and chemical changes in soil properties caused by different tillage practices. In a study of the sorption of three broad-leaf weed herbicides in two different soils under conventional and no-till conditions in the Peace River region, LRC researchers found that

- sorption was greatest for 4-chloro-2-methylphenoxyacetic acid (MCPA), followed by clopyralid, then dicamba
- in a sandy loam soil, more herbicide was sorbed under no tillage than under conventional till
- these differences were not consistent in a clay soil, in which sorption was influenced by soil organic carbon content and pH.

Management to prevent barley scald The fungus *Rhynchosporium secalis* causes scald, one of the main leaf diseases of barley in Alberta. Scald may cause yield losses averaging as high as 5–10%, with monetary loss of more than $30 million in some years. Resistant cultivars have been used to manage scald, especially in the production of feed barley. However, researchers at Lacombe and Edmonton have found that more virulent races of the scald pathogen are developing and spreading. The resistance genes in varieties such as CDC Earl, CDC Dawn, and Falcon may no longer be effective at certain locations in Alberta. Long-term management of scald will depend on

- continuing to identify potential sources of scald resistance and incorporating them into commercially acceptable breeding material
- managing the resistance already present in our western Canadian varieties.

Management to reduce barley disease LRC researchers carried out a survey of commercial barley fields under conservation and conventional tillage systems in 1995, 1996, and 1997. The aim was to assess the impact on scald and net blotch of

- tillage regime
- crop rotation
- variety resistance.

In all 3 years, substantial levels of both scald and net blotch developed in fields not planted to barley for the previous 4 years. The most likely source of disease in these fields was seed-borne inoculum. Variety resistance had a consistent influence, with each disease tending to decrease as the level of resistance increased.

Although tillage and rotation may have an influence on barley diseases, other factors also have a substantial impact on disease risk. These factors include

- environmental variation
- seed-borne inoculum
- variety.

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Mandate

The Pacific Agri-Food Research Centre (PARC) conducts research on

- production and protection of horticultural and field crops, including tree fruits, small fruits, greenhouse vegetables, special crops, and forages
- advanced processing, utilization, and quality of plant products
- cellular and molecular biology of plant pathogens of significance to agricultural crops
- soil resource conservation and land evaluation
- poultry production.

Resources

PARC is located at two sites in British Columbia, Summerland and Agassiz. The Director, Dr. Gordon Neish, is located at Summerland; the Associate Director, Dr.Valerie Stevens, is located at Agassiz.

PARC (Summerland) in the Okanagan Valley has a modern office and laboratory complex with pilot plant facilities for food research. It has a land base of 320 ha, of which about 90 ha are irrigated and available for research on tree fruit and viticulture. Current plans are to complete a $2.0-million construction and renovation of greenhouse space.

PARC (Agassiz) in the Fraser Valley operates two field sites covering 665 ha at Agassiz and two covering 16.5 ha at Abbotsford. It has modern facilities for conducting poultry and greenhouse vegetable research. Current plans are to construct an $18-million office, laboratory, and greenhouse complex by 2000.

In 1997–1998, when the achievements presented in this report were completed, the centre spent $10.6 million through their operating budget, $3.8 million from the Matching Investment Initiative, $242 thousand from other special programs, and $273 thousand in other nonfederal funding. The professional staff listed in this report are currently on staff, as of 1 April 1999. They can be contacted directly for further information on any of our programs or services.

Achievements

- *Staff awards and honors*
- *Matching Investment Initiative (MII) Program*
- *Rapid molecular diagnostic test developed for quarantined nematode*
- *Apple stem grooving virus eliminated from infected apple tissue*
- *New technique developed to detect and identify important groups of fungi*
- *Two-thirds of the little cherry virus genome cloned and sequenced*
- *Viral and vector components identified and characterized*
- *Three new cleavage sites identified*
- *Insect cell protein expression system developed*
- *Antioxidant activity of copigmented anthocyanins determined*
- *Volatile components of Echinacea species identified*
- *Antioxidant activity and total phenolics determined*
- *Anthocyanins, phenolics, and color of British Columbia red wines studied*
- *Phenolic cross-links measured*
- *Sensory properties of membrane-filtered apple juice determined*
- *Different strains of Fuji apples characterized*
- *Stripe density of apple cultivars measured*
- *Apple juice aroma and flavor described*
- *Wine judge performance evaluated*
- *Pre-cooked roast beef preserved with volatile essential oil of horseradish*
- *Processing practice for ready-to-eat lettuce improved*
- *E. coli O157:H7 reduced significantly in cider production*
- *Selection of membrane structure for juice manufacturing aided*
- *Apple juice manufacturing improved*
- *Physical and chemical characteristics of selected sweet cherry cultivars assessed*
- *Black speck minimized or eliminated*
- *Natural clay adsorbents commercialized*
- *Quality after harvest maintained by space-age reflective tarp*
- *Leafroller management demonstrated*
- *New cultivars evaluated for consumer acceptance*
- *Preferences for apple cultivars predicted by sensory evaluation panels*
- *New cultural technique developed for medicinal plants*
- *New ginseng seed stratification method developed*
- *Organic wastes used to amend sandy soils*
- *Potassium deficiency of drip-irrigated apple corrected*
- *Storage potential of apples predicted by fruit mineral analysis*
- *Blister spot found for the first time in British Columbia*
- *Fungus-resistant cover crops recommended for apple orchards*
- *Acid vapors effective against fungi causing postharvest decay*
- *Impact of climate change on agriculture summarized*
- *Characteristics of apple market and product quality analyzed*
- *Contribution of plant breeding to*

improvements in canola yields determined
- *Fireworm moth mating and reproduction prevented*
- *Detection and control of obliquebanded leafroller improved*
- *Publication on beneficial insects now available on the Internet*
- *Variations in carabid ground beetle numbers determined*
- *Pythium in greenhouse cucumber effectively controlled*
- *Nitrogen utilization dynamics in broccoli characterized*
- *Shelf life of long English cucumber predicted*
- *Chlorophyll fluorescence used to monitor postharvest conditions of greenhouse cucumbers*
- *Crops under stress detected by infrared imaging*
- *Root rot managed in lettuce*
- *Sleighfoot manure applicator proven beneficial*
- *Nitrate pollution of groundwater reduced*
- *Ammonia emissions from poultry barns reduced, not recovered*
- *Research project designed to expand NIRS technology*
- *Factors affecting palatability of western Canadian cereals for poultry confirmed*
- *Phosphorus excretion reduced*
- *Feed-grain feeding value predicted for various species*
- *Sustainability promoted by better management practice*

Staff award and honors G.H. Neilsen, P. Parchomchuk, R. Berard, and D. Nielsen received the C.J. Bishop award for the best fruit paper published in the Canadian Journal of Plant Science in the previous year, 1997.

G. Mazza received the Canadian Institute of Food Science and Technology Fellowship Award for outstanding scientific leadership in food science and technology.

E. J. Hogue, collaborating scientist, received the award of Honorary Life Member of the Canadian Society for Horticultural Science for service to the society and to horticulture in Canada.

W. D. Lane received the 1998 Outstanding Cultivar Award from the Canadian Society for Horticultural Science for Lapins Sweet Cherry.

Matching Investment Initiative (MII) Program The MII program and matching private sector cash and in-kind contributions comprise about 30% of the centre's total budget. The projects carried out under the MII program are linked to the centre's core research activities. Many of the achievements listed on the following pages have been partially supported by AAFC MII private-sector partnerships.

Rapid molecular diagnostic test developed for quarantined nematode The Columbia root-knot nematode is a severe pest of potato, causing millions of dollars of losses. It has not spread to Canada, thanks to a quarantine by the Canadian Food Inspection Agency. For quarantine purposes it is crucial to differentiate between this nematode and other less-damaging species. The only reliable identification test takes several weeks, making it impractical in most situations. PARC researchers have developed a very rapid molecular test using signature DNA sequences that are not found in other root-knot species. This accurate, reliable detection test can now be used to certify seed potatoes exported from or imported into Canada.

Apple stem grooving virus eliminated from infected apple tissue Effective methods to eliminate plant viruses from infected clonal material are an important component in breeding programs for perennial crops. Improved detection methods for plant viruses
- enhance diagnosis of diseases within Canada
- facilitate access by Canadian industry to international germplasm by reducing the time for passage of plant material through quarantine programs.

Apple stem grooving virus (ASGV) is regarded as one of the most difficult viruses to eliminate by standard heat therapy practices.

PARC researchers used a novel chemotherapeutic technique to eliminate this virus from infected apple tissue. The technique uses a combination of

- quercetin, a naturally occurring plant flavonoid
- ribavirin, a synthetic anti-viral compound.

A sensitive immunocapture RT-PCR procedure for detecting ASGV was developed to assess virus elimination.

New technique developed to detect and identify important groups of fungi Species from the genus *Pythium* can infect any crop but are particularly damaging

- in greenhouses
- on graminaceous hosts, such as turf or cereals
- in replant problems.

It is important to be able to distinguish between these fungi and other species that are not harmful. However, detecting and identifying fungi by conventional means is often time consuming and requires the skills of taxonomic specialists.

PARC researchers have developed a multiplex assay to detect and identify *Pythium* species. This assay is the first of its kind in the field of mycology or plant pathology, and its capability for expansion is unlimited. The reverse dot-blot hybridization assay eliminates the need for fungal isolation and also detects and differentiates several *Pythium* species in a single test. The technique has been tested in both government and private diagnostic laboratories on turfgrass samples. A similar technology to detect the key pathogens of cranberry is currently being evaluated in the field for spore monitoring and fruit rot prediction.

Two-thirds of the little cherry virus genome cloned and sequenced Little cherry virus (LCV)

- has caused severe economic loss in cherry trees in British Columbia
- has been detected in most other cherry-growing districts in the world
- still represents a threat to the cherry-growing industry.

Available methods for control and detection of LCV rely heavily on field indexing of woody indicator trees, which

- is time consuming
- frequently gives negative results from infected trees.

Current research aims to develop a rapid, sensitive diagnostic procedure for LCV infection.

About two-thirds of LCV's genome has now been cloned and sequenced, including the LCV coat protein gene. Cloning of this gene will enable the development of polyclonal antisera to LCV. These antisera can be used for rapid, sensitive, and reliable detection and, ultimately, control of LCV.

Viral and vector components identified and characterized Most plant viruses require a specific invertebrate or fungal vector for efficient transmission in nature, but little is known about the interactions that promote attachment of viruses to their vectors. In their work to identify and characterize viral and vector components required for effective virus–vector interactions, PARC researchers have found

- particular regions of the coat protein of cucumber necrosis virus (CNV) that are required for virus transmission or attachment of CNV to its fungal vector
- a specific receptor-like molecule on the fungal vector, which is required for CNV attachment.

Such findings will aid in the development of new, environmentally sound procedures for controlling the spread of viruses.

Three new cleavage sites identified New methods are being developed to control plant virus diseases. These offer an alternative to using pesticides indirectly against the insects or nematodes that transmit plant viruses.

Three new cleavage sites have been identified. These are recognized by a viral protease from tomato ringspot nepovirus. This development provides information on the cleavage site specificity of the viral protease. In-depth understanding of these proteases is required to design inhibitors that will be specific to viral proteases and not to other enzymes. Such inhibitors could be expressed in transgenic plants to provide increased resistance to plant viruses.

Insect cell protein expression system developed One of the key technologies for the biotechnology industry is the expression and production of recombinant proteins for research and commercial uses in agriculture and medicine. PARC researchers have developed a novel protein expression system that can continuously produce significant quantities of complex biologically active proteins in insect cells. Developed with researchers at the University of British Columbia, this system

- has the significant advantage that it can be used in a variety of insect cell types
- can produce complex protein products with higher fidelity and in larger amounts than the most widely used baculovirus expression systems.

This system has been licensed for commercial worldwide marketing purposes to a leading biotech expression company. Patents have been filed in the United States and Canada.

Antioxidant activity of copigmented anthocyanins determined Copigmentation of anthocyanins with naturally occurring phenolic acids, such as chlorogenic acid, greatly increased the antioxidant activity of the pigment and copigment mixtures. This information is required to understand biologically active food components that promote health.

Volatile components of Echinacea species identified PARC researchers analyzed the headspace for volatile components of roots, stems, leaves, and flowers
of three species of *Echinacea*:

- *E. angustifolia*
- *E. pallida*
- *E. purpurea.*

Of the more than 70 compounds identified, more than 50 are reported for the first time for *Echinacea*. This information contributes to the identification of the constituents of *Echinacea* species used as herbal drugs throughout the world.

Antioxidant activity and total phenolics determined PARC researchers determined the antioxidant activities and total phenolics of 28 plant products, including

- sunflower seeds
- flaxseeds
- wheat germ
- buckwheat
- several fruits
- several vegetables
- several medicinal plants.

The correlation coefficient between total phenolics and antioxidative activities was statistically significant. This information is required for improved understanding of food products, especially those touted to possess health-enhancing properties.

Anthocyanins, phenolics, and color of British Columbia red wines studied PARC researchers studied changes that took place during ripening of grapes, vinification, and aging of several British Columbia wines in

- anthocyanins
- flavonols
- total phenolics.

Variety and season influenced the contents and composition of anthocyanins and colorless phenolics in grapes and wines. This information is required for the production of wines

- with desirable sensory characteristics
- rich in biologically active components.

Phenolic cross-links measured Cell wall carbohydrates are cross-linked by phenolic compounds. These cross-links have recently been implicated in determining the textural property termed "crispness" in fresh and processed vegetables and perhaps fruit. PARC researchers have developed a method based on the saponification of the phenolic cross-links using dilute base. The method holds promise as

- a chemical measure of texture
- an aid in selection for breeding purposes.

Sensory properties of membrane-filtered apple juice determined PARC researchers evaluated shelf-stable apple juices, prepared using a new nonthermal process called membrane filtration. These novel juices

- had the distinctive green flavor of a freshly cut apple
- lacked the cooked–caramelized aromas associated with conventional processing.

The industry has created new juices with unique sensory characteristics. These products are of potential interest to a different segment of the consumer market.

Different strains of Fuji apples characterized PARC researchers found that four commercial strains of Fuji apples that look very different taste the same. This information is important to scientists, horticulturists, and growers.

Stripe density of apple cultivars measured The success of new striped apple varieties in the marketplace has created a need to objectively transfer the stripe density into new and promising cultivars. PARC researchers have developed a method that uses photographic images to allow consistent judging. This work aids in effective communication among plant breeders and marketers.

Apple juice aroma and flavor described PARC researchers have developed a lexicon for characterizing apple juice by
- defining attributes
- developing reference standards.

This knowledge will be used to more objectively monitor changes in juice characteristics for quality control and research and development.

Wine judge performance evaluated PARC researchers have used a novel plotting technique to track the reliability and performance of professional wine judges. It has given wine competition coordinators an objective tool for
- evaluating judges
- improving the quality and reputation of wine competitions.

Pre-cooked roast beef preserved with volatile essential oil of horseradish Rapid microbial growth and organoleptic changes resulting from oxidation of fats and meat pigments severely limit the shelf-life of precooked meats. Adding volatile horseradish essential oil to the head space above pre-cooked roast beef slices
- restricted the growth of most spoilage bacteria
- led to the retention of typical cooked meat color
- delayed the development of off-flavors and odors derived from fat oxidation products.

The antimicrobial activity of isothiocyanates in essential oils from cruciferous plants has been documented. However, the antioxidant properties of these natural compounds is a new observation.

Processing practice for ready-to-eat lettuce improved Current commercial practice for the manufacture of ready-to-eat lettuce
- has limited microbial efficacy for washing and disinfection
- uses a method of water removal that is impractical for continuous processing.

An alternative processing scheme developed at PARC consists of a disinfection step under mild heat, followed by drying in a forced-air drier designed for the purpose. The treatment leads to an overall improvement in shelf-life as a result of
- enhanced destruction of contaminating microorganisms
- reduced browning during subsequent storage.

Both results benefit the industry.

E. coli O157:H7 reduced significantly in cider production Outbreaks of food-borne illness have been linked to the consumption of apple cider contaminated with *Escherichia coli* O157:H7. Washing with conventional sanitizers does not significantly reduce *E. coli* numbers on apples. Extensive destruction of the bacterium has been achieved with both
- a novel peroxyacetic acid based sanitizer
- a 5% acetic acid solution in combination with mild heat (55° C).

Selection of membrane structure for juice manufacturing aided Information was needed to design superior membrane systems for use in juice manufacturing. PARC researchers compared the fouling behavior of various polymeric membranes with diverse
- surfaces
- hydrophobicities
- pure water fluxes.

Compared with smooth membranes, rough surfaces produced fouling layers that
- were less dense and more open
- had lower flux resistances.

This information can be used in developing new products in the juice manufacturing industry.

Apple juice manufacturing improved During production, some components in apple juice tend to accumulate on the membrane surface. This
- leads to reduced flux
- often limits membrane system productivity.

PARC researchers used model solutions of pectin, tannin, and protein to determine

- what specific molecular forces and colloidal functional groups causes aggregate formation
- the resulting effects on fouling layer resistance.

This information will benefit the industry by helping to identify optimal performance conditions for membrane processes.

Physical and chemical characteristics of selected sweet cherry cultivars assessed To compare commercial sweet cherry cultivars with promising new selections, PARC researchers used instrumental methods to examine

- 50 volatile components
- nine nonvolatile flavor components
- standard quality attributes.

Such detailed assessments strengthen our understanding of

- the differences and similarities in composition among sweet cherries
- the determinant flavor relationships.

This work supports the effort toward sustaining a competitive fruit industry in Canada.

Black speck minimized or eliminated Black speck, a serious storage disorder for broccoli, kept a Quebec grower–shipper from getting the best possible returns. He was not able to store his broccoli until market conditions were optimum.

In collaboration with the Horticulture Research and Development Centre at Saint-Jean-sur-Richelieu, a PARC scientist determined that the disorder could be minimized through

- cultivar selection
- storage atmosphere.

The grower–shipper is now investing capital to adapt the recommendations to his operation.

Natural clay adsorbents commercialized Certain natural clays can help to preserve freshness in packaged, minimally processed fruits and vegetables by

- removing deleterious volatiles from tissue
- adsorbing these volatiles once they are emitted into the package atmosphere.

This technology's effectiveness has been demonstrated with 3 years of laboratory testing. The technology is currently being commercialized by a British Columbia company that will be selling the product to the international fresh-cut industry.

Quality after harvest maintained by space-age reflective tarp Special laminated Mylar tarpaulins almost completely eliminated stem browning in harvested sweet cherries. Fruit quality was also much better after 6 weeks' storage in modified atmosphere packages. The tarpaulin provides an efficient deep-shade effect that

- prevents heat-loading of the fruit
- minimizes precooling requirements
- avoids heat-induced injuries.

This technology is being considered for use by the sweet cherry industry, as well as by the raspberry and blueberry industries.

Leafroller management demonstrated Apple growers in some regions of Quebec have had problems controlling leafroller pests because the larvae have become resistant to insecticides. A collaborative study between PARC and the Horticulture Research and Development Centre has shown that

- this resistance is unstable
- leafrollers revert to susceptibility in three to five generations when removed from insecticide selection pressure.

These findings demonstrate that management of resistant leafrollers is possible using a strategy of rotating the application of different types of insecticides.

New cultivars evaluated for consumer acceptance Work by researchers from PARC and the Atlantic Food and Horticulture Research Centre shows that

- eastern and western consumers prefer different apple cultivars based on visual appearance
- their preference for flavor and texture is similar.

This information is important to plant breeders for the selection of successful new cultivars.

Preferences for apple cultivars predicted by sensory evaluation panels In-house sensory panels have successfully predicted consumer preferences for new apple cultivars. This finding provides plant breeders with a more economical way to make selections from a large number of cultivars in the breeding program.

Using evaluation panels will give them confidence that their selections will be accepted in the marketplace.

New cultural technique developed for medicinal plants PARC researchers have developd a new hydroponic and organic cultural technique under a controlled environment for medicinal plants. This new technique will

- reduce cultivation periods
- avoid unfavorable weather conditions
- reduce soil-borne diseases
- reduce environmentally hazardous chemical applications
- improve active ingredients.

New ginseng seed stratification method developed PARC researchers have developed a new ginseng seed stratification technique under a controlled environment. It provides

- suitable temperatures and adequate moisture levels for embryo development during stratification stages
- monitoring for disease incidences.

This method can

- shorten the ginseng seed stratification period from 18–22 months to seven months
- increase seed viability
- increase seedling uniformity.

Organic wastes used to amend sandy soils PARC researchers have completed a 3-year field trial that tested the potential of various wastes as soil amendments in horticultural production systems. The work was undertaken with municipal and private collaborators. Results showed that adding organic wastes to an irrigated, sandy soil improved the yields of carrots and chard, compared with plants receiving fertilizer only. Many biowaste and biosolid products can be used in horticultural production, providing a relatively inexpensive and environmentally sustainable source of plant nutrients.

Potassium deficiency of drip-irrigated apple corrected PARC researchers identified a potential for potassium deficiency in drip-fertigated orchards on coarse-textured, sandy soils. Left uncorrected, such a deficiency could seriously reduce growth and yield of high-density apple orchards after 3 years. Midsummer leaf potassium concentrations could be increased by applying potassium at rates of 15–30 g per tree.

Storage potential of apples predicted by fruit mineral analysis In collaboration with a local shipper, PARC researchers have completed a multi-year study to identify key factors associated with storage disorders in three commercially important apple cultivars:

- McIntosh
- Spartan
- Golden Delicious.

The study showed that storage disorders tend to increase

- with low fruit calcium concentration
- with high fruit mass (large fruit)
- with low fruit calcium/potassium ratios.

Information generated from this study provided a mechanism for early detection of fruit likely to exhibit poor storage quality. It is currently being used by a major packing house to upgrade the quality of fruit placed in long-term storage.

Blister spot found for the first time in British Columbia Blister spot was found for the first time in British Columbia. This bacterial disease is well known on the apple cultivar Mutsu (Crispin) in eastern North America. Control is difficult and requires the use of copper-based fungicides. Fuji apples were almost as susceptible as Mutsu in trials conducted at PARC. The concern in British Columbia is that the disease may spread from Mutsu to the newer cultivars. Orchardists must be alerted to the importance of preventing its spread.

Fungus-resistant cover crops recommended for apple orchards Low-temperature basidiomycete (LTB) can cause severe losses in stored apples. The orchard cover crop acts as a source of inoculum for the fungus. Mixed grasses with a clean strip in the tree row is the most desirable cover when horticultural factors and LTB rot are both taken into consideration. Knowledge that the choice of cover crop influences decay could persuade orchardists to plant cover crops that are resistant to the LTB fungus.

Acid vapors effective against fungi causing postharvest decay Acetic and propionic acids are used by food manufacturers as antimicrobial preservatives. Formic acid is used in many industrial processes. All three acids were tested as vapors. They were found highly effective in destroying spores of three different fungi that cause postharvest decay, without damaging the fruit:

- Acetic acid may soon be used to reduce decay in pears.
- Propionic acid vapor is most suited to controlling cherry decay.
- Formic acid could find a use as a general disinfectant in fruit and vegetable storage.

These acids could replace some of the more toxic substances that are currently used.

Impact of climate change on agriculture summarized The impact of climate change on agriculture is a concern. A review paper showed that the land base for agriculture in British Columbia will change under

- increased temperatures in northerly regions
- increased drought in southerly valleys of interior British Columbia.

This information will be useful in reducing speculation and assisting producers to prepare for the predicted changes.

Characteristics of apple market and product quality analyzed With the proliferation of new varieties marketed over the last 5–8 years, implicit market values for product traits must be derived so that a focused breeding strategy is pursued. This strategy recognizes

- changing consumer attitudes related to apples
- growing market competition from Southern Hemisphere countries.

PARC researchers conducted an analysis of market and product-quality characteristics of apples marketed by B.C.Tree Fruits Limited, including

- storage method
- grade
- apple size
- package size.

The purpose was to pinpoint which characteristics are associated with price premiums and which are related to price discounts. The work provides marketers and breeders with information on what traits wholesalers and retailers value.

Contribution of plant breeding to improvements in canola yields determined Genetic yield potential and product quality have increased markedly over the last two decades. But the impact on production has not been well documented. With the Brandon and Saskatoon research centres, PARC researchers determined the contribution of plant breeding to improvements in canola yields over the last 18 years in Manitoba.

The study addressed

- the effect of weather and location on product quality and yield by variety over time
- whether canola yield patterns suggest that a plateau has been reached
- the rate of canola varietal replacement on farms
- the impact of Canadian Plant Breeders' Rights (1990) on canola yields.

Results of this study are an important measure of

- the impact of plant breeding programs
- the extent of varietal diversification
- the potential susceptibility to disease caused by the breakdown of resistance.

Fireworm moth mating and reproduction prevented A major North American cranberry pest, the blackheaded fireworm *Rhopobota naevana*, is controlled in Canada with registered pesticides.

Working in partnership with industry since 1992, PARC researchers have developed a nonpesticidal technique to prevent fireworm moths from mating and reproducing. Pheromone-mediated mating disruption uses a synthetic version of the insect's sex attractant pheromone to confuse male moths and prevent them from finding females. This sustainable technology has been registered in the United States and is pending in Canada.

Detection and control of obliquebanded leafroller improved The obliquebanded leafroller *Choristoneura rosaceana* feeds on raspberry leaves and fruit and drops into bins of machine-harvested fruit. Three years of work to improve detection and control of these harvest contaminants has benefited the raspberry industry.

A new sampling program allows growers to detect leafrollers before they become a problem. Work on microbial *Bacillus thuringiensis-based* insecticides has provided information to help growers

- maximize leafroller control
- minimize the use of conventional pesticides.

Publication on beneficial insects now available on the Internet The AAFC publication *Beneficial insects and common pests on strawberry and raspberry crops* is now available at the PARC website. Accessibility to this kind of information is key to educating people about beneficial insects. This is an important step toward sustainable agricultural practices through the development and acceptance of integrated pest management.

Variations in carabid ground beetle numbers determined Growers of field crops usually cannot afford mass-reared arthropods for pest control. Carabid ground beetles are generalist predators that feed on important pests and are already present in most fields. A monitoring protocol resulting from an intensive study of carabids in raspberry fields has revealed large variations in carabid numbers between fields. This variation is important because there are factors that growers may be able to manipulate to

- increase predator populations
- better control pests.

Pythium in greenhouse cucumber effectively controlled The greenhouse industry is moving from drain-to-waste fertigation to more economical and environmentally friendly recirculating nutrient systems, in which leached fertilizers are captured and re-applied to the crop in a closed loop. The major obstacle is the spread of root diseases. PARC researchers have developed inexpensive slow filtration systems to effectively control *Pythium*, a major root pathogen of greenhouse-grown cucumber plants.

Nitrogen utilization dynamics in broccoli characterized Broccoli plants were shown to recycle nitrogen from leaf tissue for head development when nitrogen levels are low in the soil, at the end of the growing season. Because the crop is so efficient at utilizing nitrogen, a low rate of nitrogen fertilizer applied as a single, rather than split application, can be recommended to growers.

Shelf life of long English cucumber predicted The shelf life of long English cucumber varies widely among individual fruit. So cucumbers should be sorted for long shelf life before they are packed. Research at PARC has shown that shelf life can be partially predicted at harvest by cucumber fruit color, which has been successfully measured by video imaging.

Chlorophyll fluorescence used to monitor postharvest conditions of greenhouse cucumbers Greenhouse cucumbers can become yellow during postharvest distribution, resulting in losses for producers. PARC researchers have been looking at parameters to identify some of the storage conditions that cause premature yellowing. Chlorophyll fluorescence can be a useful tool in monitoring

- chilling injury
- long duration of normal storage.

Under known conditions, some fluorescence parameters may be useful as quality indicators for postharvest handling procedures of greenhouse cucumbers.

Crops under stress detected by infrared imaging Moisture stress during crop production might not be detected by human eyes, particularly during a moderate water shortage, such as that caused by the partial blockage of irrigation tubes in greenhouse vegetable production.

A technique has been developed to use an infrared imaging system for early detection of plant stress. Infrared images

- display an increase in foliar temperature in water- stressed plants before wilting is visible
- detect decay early in winter squash during storage.

This nondestructive, noncontact method is useful in plant science research and commercial greenhouse production.

Root rot managed in lettuce Root rot, caused by *Pythium aphanidermatum*, is an acute problem in recirculating nutrient systems in greenhouses. PARC researchers have developed methods for managing root rot of lettuce in greenhouses. Lettuce production can be increased by applying

- Boost (*Bacillus subtilis*)
- Promo (nutrient supplement)
- Agrol (Amway).

This research will aid in improving the production capabilities of greenhouse lettuce growers.

Sleighfoot manure applicator proven beneficial Manure slurry spread with the sleighfoot applicator developed in western Europe can be used reliably to replace fertilizer nitrogen for grass crops. PARC research with this new technology is the first in North America.

Compared with the conventional splash plate, the sleighfoot

- applies slurry uniformly in all weather
- eliminates crop contamination
- gives more time to spread
- reduces odor
- is cheaper and faster
- requires less tractor power
- can be used on stony land
- does less root damage to forage crops than slurry injectors.

As a result of the work at PARC in cooperation with a local conservation group, a Vancouver Island farm is believed to be the first commercial user of the sleighfoot in North America.

Nitrate pollution of groundwater reduced An autumn soil nitrate test recently developed at PARC provides an objective tool for raspberry growers

- to determine appropriate levels of nitrogen
- to help prevent excessive applications.

Use of this tool has resulted in large reductions of nitrogen application, especially as manure, on raspberry plantings over the Abbotsford–Sumas groundwater aquifer. Poultry farmers sited over the aquifer are now trucking some of their manure to other locations in British Columbia instead of spreading it on the land. This action will eventually reduce nitrate pollution of the aquifer, which is a source of water for communities in Canada and the United States.

Ammonia emissions from poultry barns reduced, not recovered Emission of ammonia from animal buildings

- may produce odor problems
- may cause soil acidification in the vicinity
- represents the loss of valuable plant nutrient nitrogen from the manure.

Ammonia emissions from large commercial high-rise and shallow-gutter layer poultry barns were estimated to range from 5 to 90 mg/h per bird. It is not economical to recover the ammonia in the exhaust air. But management methods to help reduce emissions are recommended.

Research project designed to expand NIRS technology Near infra-red spectrometry (NIRS) is an accurate, nondestructive, extremely rapid and user-friendly technology capable of predicting the feeding value of grains and subsequent bird performance. PARC researchers have now designed a 3-year research project to expand this technology. NIRS has the potential to automatically adjust diet formulations as grains are tested when they enter the feed-mixing system. More accurate diet formulations will

- reduce variability in the field
- greatly enhance the sustainability of the industry by reducing the need to over formulate.

NIRS will have immediate application by cereal geneticists to screen new cultivars for such characteristics as

- improved feeding value
- food and malt value
- yield
- disease resistance.

NIRS is expected to be used to develop new agronomic practices that increase the feeding value of grains, thereby increasing market acceptance and the price paid to producers.

Factors affecting palatability of western Canadian cereals for poultry confirmed An initial study was done involving different sources of freshly harvested wheat and hulled and hulless barley. It found significant changes in the voluntary intake by poultry of these ingredients after 6 months' storage. This work confirms that there are factors in western Canadian cereals that

- affect the palatability for poultry
- are reduced with storage.

More research is necessary to determine these factors.

Phosphorus excretion reduced About two-thirds of the phosphorus stored in feed grains is not available to poultry. So the diets are supplemented with costly inorganic phosphorus. But phosphorus excretion by poultry is a serious concern for the sustainability of the industry. Phosphorus from manure is implicated in eutrophic algal growth in surface waters.

A study with laying hens has demonstrated that sources of inorganic phosphorus can be reduced by adding a commercial phytase enzyme to feed. The enzyme

- improved the availability of plant phosphorus
- reduced the amount of phosphorus excreted by the birds to nearly 50% of the standard control-based diets.

Feed-grain feeding value predicted for various species Determining the feeding value of feed grains requires slow and very expensive bioassay measurements. It has been difficult to predict if a feed grain's feeding value measured with poultry was the same when fed to pigs. A recent study with pigs and broiler chicks demonstrated that

- the relative feeding values with the various species were low when the diets were fed to broilers without enzyme
- the relative rankings of the diets for pigs and broilers were extremely high when the barley-based diets were combined with enzyme.

This information could

- significantly affect the bioassay information
- be applied to several species
- speed the development of NIRS for wide-scale screening of feed grains for feeding value.

Sustainability promoted by better management practice Applying manure to winter cover-cropped corn land resulted in 50% reductions in

- soil loss
- the transport of nitrogen, phosphorus, and potassium.

This better management practice

- benefits producers and the industry by conserving soil and nutrients for crop production
- contributes to a better, more sustainable environment by reducing impacts on surface water quality.

Increased environmental regulation in the Lower Fraser Valley of British Columbia defines when not to spread manure because of the risk of water pollution. This new management practice allows producers to spread manure later in the fall and earlier in the spring.

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